ILLUSTRATIONS

OF

VEGETABLE PHYSIOLOGY.

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VEGETABLE PHYSIOLOGY,

PRACTICALLY APPLIED,

TO

THE CULTIVATION OF THE GARDEN, THE FIELD, AND THE FOREST;

CONSISTING OF

ORIGINAL OBSERVATIONS,

COLLECTED DURING AN EXPERIENCE OF FIFTY YEARS.

BY JAMES MAIN, A.L.S.

Author of "The Villa and Cottage Florist's Directory," and Editor of the last editions of Mawe's "Every Man his own Gardener," "Greenhouse Companion," &c.

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BRADBURY AND EVANS, WHITEFRIARS,
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TO

J. E. BICHENO. F. R. L. G. & Z. Soc.

AS

AN ADMIRER OF NATURE AND NATURAL PHILOSOPHY,

CONVERSANT WITH THE SUBJECT TREATED OF IN THE FOLLOWING PAGES

AN ENCOURAGER OF EVERY BRANCH OF RATIONAL SCIENCE,

AND, ABOVE ALL,

ACTUATED BY THE MOST LIBERAL AND UNBIASSED PRINCIPLES

RELATIVE TO WHATEVER HAS BEEN OR MAY BE PROPOUNDED

ON SUBJECTS OF NATURAL HISTORY,

This Volume

IS RESPECTFULLY DEDICATED,

BY HIS MOST OBEDIENT AND OBLIGED SERVANT,

JAMES MAIN.

CONTENTS.

PREFACE.

NOTWITHSTANDING Vegetable Physiology has engaged the attention of some of the most distinguished naturalists in Europe, it is still but imperfectly understood. The highest authorities are not yet agreed on the subject, differing in opinion, as well concerning the motions of the fluids, as in respect of the manner of accretion of what may be called the solids of plants.

Hitherto the science has been in some degree obscured by the terms employed in its illustration. It has been explained too frequently by references to animal anatomy; and because there are resemblances in some particulars, a too general idea has been entertained, that the whole of the

one might be understood by reference to the other. This has tended to check investigation, by withdrawing the attention of the student from the phenomena, and inducing him to be satisfied with vague assertion rather than actual proof.

But as mere fictitious knowledge cannot be useful, it is necessary, especially for young practitioners, that the science should be divested, if possible, of some of its superfluous disguise, and treated of in such language as shall be equal to every capacity.

Under these impressions the following pages have been written, and intended to bear a *popular* rather than a scientific character, with the sole view of assisting, by familiar explanation, the various practice of the gardener and woodman. In fact, the principal feature of the book is an attempt to explain only what has been obscurely or *too learnedly* treated before; to mention circumstances which, though generally known, have never appeared in print; and to make up for deficient language by explanatory figures of the visible constituents of plants: the intention being,

however, only to mark the greater parts, their limits, and their connections, leaving the minor and less striking portions of vegetable structure to those who may have better opportunities to examine and describe them.

On this plan the work will be found a compendium of the discoveries and best authenticated facts which have appeared in the writings of others, and which have been *proved* in the practice and experience of the writer, or in that of his cotemporaries, during the last fifty years. He trusts that new matter enough will be found to justify the publication; and though but a rough sketch, which from his very limited knowledge of chemistry he has not been able to fill up as he wished, still he entertains a hope that, such as it is, it may receive amplification from an abler pen, and accomplish his aim of rendering vegetable physiology better and more generally understood.

As many of the ideas in the first essays are detailed without proofs, the latter will be found

in the sections which follow, and where they are practically applied.

Relative to the arrangement of the book, and the style in which it is written, the author feels it necessary to apologise to the reader for much reiteration. It has been his study to use the plainest language, as most natural to himself and best suited to those for whom he presumes to write. The major part of the essays have been long in manuscript; additions and interlineations having been made from time to time, as new or more correct ideas occurred. This manner of compilation has occasioned a want of connection, which could not be remedied without the exercise of a talent which the author does not sufficiently possess. He hopes, however, that such will not be considered a blemish; and trusts that in those instances where he differs most from the opinions of others, he has shown good reasons for so doing, and without expressing himself so dogmatically as to weaken the force of his representations.

To his botanical friends, A. H. Haworth, Esq.; Mr. Anderson, Curator of the Physic Garden, Chelsea; and to Mr. Don, Librarian of the Linnæan Society of London, he returns his best thanks, for the readiness with which these gentlemen severally answered every question proposed to them on the subject.

The figures, chiefly outlines, have been drawn by E. D. Smith, F. L. S., from nature, in all cases when necessary; some of them are *ideally* extended, but not without a close imitation of the structure shown by the microscope. Superior execution has not been aimed at, because an accurate outline gives as perfect an idea as the most finished drawings, especially of such parts as are invisible to the naked eye; neither have these figures been too much multiplied, because this would have been adding expense without any real value. In fact the brevity intended did not allow of much extraneous matter.

ERRATA.

Page 29, top line, *read* " of *the* common."
– 34, seventh from bottom, for " evolves," *read* " involves."
– 49, in the reference to Fig. 18, *read* " the following spring."
– 82, thirteenth line, for " back," *read* " bark."
– 94, fourth line above note, *read* " Tectonia."
– 193, twelfth line from top, for " outlets," *read* " rootlets."
– 211, third line from top, for " on," *read* " in."
– 221, bottom line, for " and are," *read* " which expedient is."

ILLUSTRATIONS

OF

VEGETABLE PHYSIOLOGY.

I.—VEGETATION, VEGETABLE ELEMENTS AND STRUCTURE.

The vegetable kingdom is one of the grand divisions of nature; without this animals would have been created in vain; the vast masses of minerals would have appeared a cheerless waste, had not plants sprung forth to clothe and embellish the earth, yielding food and raiment, shade and shelter, directly or indirectly, to all that live.

Vegetables are organised beings—endowed with motability, which is called life, but without sensation, unless their powers of contractility and irritability may be so deemed. They are formed of elements fitted for expansion—recipients of nutrition—laboratories of divers qualities—capable of reproduction—and at last dissolvable into their first principles.

Fixed to the soil they are expanded either therein, or in the air or water. The tribes of trees and herbs which cover the face of the earth, though more varied in form and colour, are scarcely more numerous than the *Fuci** which inhabit the shores and depths of the ocean.

Vegetables are said to perform an important office in the scheme of creation, in maintaining an equilibrium among the constituents of the atmosphere, by which its salubrity is improved for the purposes of animal life.

In describing the elementary matter or membrane of vegetables, it will not be necessary to notice its various disposition as presented to us by the microscope, in the different stages of its advancement from primitive indistinctness to its perfect form in the organisation: suffice it to notice in this place, that it is not a homogeneous solid, but an areolated mass, composed of innumerable vesicles arranged in different forms: either extended into filaments and fibres—spread out into tissues—depressed into horizontal layers—compressed into perpendicular partitions—or disposed in regular columns.

Vegetable element is said to be composed of oxygen, hydrogen, carbon, and some other bodies detectible by chemical analysis. This combination of immaterial bodies, forming a visible and tangible substance, is of itself a mysterious circumstance; but when we see that the most concrete and durable

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* Sea-weeds.

of vegetable products is capable of complete dissolution, without any notable residuum, we are constrained to admit that the conclusion of the chemist is just.

When the elemental membrane is uniform in consistence and arrangement, it is called *cellular;* when varied by being disposed into tubes and other organs, it is said to be *vascular*.

The microscope has assisted us to discover the constitutional fabric of the cellular matter. Each cell is an insulated vesicle, having a thin, pellucid, elastic integument; originally inconceivably minute, but capable of being distended to a limited size, but in a definite order incident to the plant to which it belongs, and in any direction; the cells leaning and super-posed on each other, and consequently pressed into the various figures of spheres, spheroids, hexagons, or elongated squares or ovals—forming the specific structure and organs of the plant. There are also intercellular spaces, which serve for the conduction of fluids, or depositories of the secretions of the plant.

A microscope of sufficient magnifying power has too confined a field of view to take in any considerable portion of cellular matter, to allow of its being accurately represented by the engraver. Sections, in whatever direction made, never show a regular disposition of the cells, because they, being of irregular form, and irregularly placed with respect to each other, present, when incised, different forms to the

eye. This will be easily conceived by looking at a slice of common sponge; but the annexed sketches will assist to give a better idea of its structure than any language which it is in the writer's power to employ. Of course they are drawn highly magnified for the sake of distinctness.

The sketch, Fig. 1, represents cellular matter as it appears when expanded perpendicularly, as in the pith, in the leaf-stalks of herbs, and in other parts of plants.

Fig. 1.

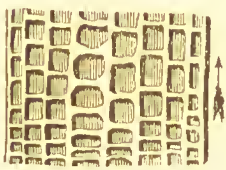
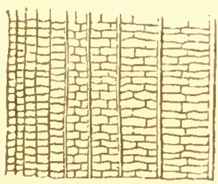


Fig. 2 shows it as swelling laterally, from right to left, as in the concentric layers of wood.

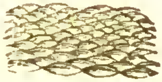
Fig. 2.



In the crown of an *Agaricus** it appears depressed, as at Fig. 3.

* Mushroom.

Fig. 3.



And Fig. 4, compressed into dense plates, as found in the medullary rays, and other parts of the stem, flowers, and fruit.

Fig. 4.

The cellular body appears to have no determinate limits, on which account it has been supposed to be self-productive: it continues to increase and protrude in every direction, if any vacancy is to be filled up, or any part of the organisation to be completed. The organs are all formed of it, and it is the material that unites them together.

The exterior of a cellular body, when exposed to the air, is always condensed into cuticle or bark; and from this effect, viz. the hardening action of the sun and air, we invariably see it, in the act of expansion, *descending* with more rapidity than increasing in any other direction.

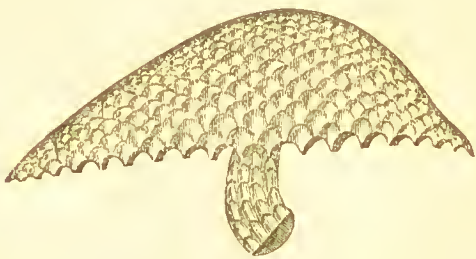
This circumstance is exemplified by the upper side

of a wound on the stem of a tree healing over more rapidly than the other sides; by the under sides of horizontal stems or branches being farther extended from the pith than the upper; and by any deformity on a stem increasing downward faster than in any other direction.

The pellicles of the cells are of various consistence and properties as to durability. In the lower orders of *cellulares*, as *Fungi** for instance, they are mucilaginous and fugitive; in the higher orders of *vasculares* they become ligneous; and, along with the secreted juices of the plant, constitute what is called timber.

Such plants as are wholly formed of cellular matter, gain magnitude by a uniform swelling motion from the centre outwards, Fig. 5. This

Fig. 5.



progressive growth is continued for a longer or shorter time according as the exciting circumstances are more or less favourable. A *Boletus* † may be increased from a mere speck to a disk of two feet in diameter; and the common mushroom varies

* Fungus. † The tree fungus.

in size, from that of a pea, to a circumference of three feet.

All cellular matter is, by a fundamental law of nature, arranged into the specific forms of the organisation and specific structure of every different kind of plant; distinguishing them from each other in form, colour, and all other physical properties.

II.—ORGANISATION.

The economy of vegetation requires a certain apparatus or system of organs. These are principally the vital, nutritive, conducting, preservative, and reproductive.

The vital organs are those parts of plants in which the life resides, and whence all the growth and expansion of the different members originate. In a seed, it is the embryo of the future plant; and this, after it is developed, continues possessed of vitality variously located in the fabric, according to the nature or peculiar conformation of the plant itself. In some it has a fixed station; whence all divisions proceed. It is so located in bulbous and tuberous stems, and in what is called the crown of many herbaceous plants. In the case of shrubs, trees, and many suffruticose and herbaceous plants, the vital principle is not confined to one place, but is borne up with and spread over the exterior of the stem and branches, sometimes into the leaves, and over the surface of the wood in the roots also. When existing as in a seed it is called the *corculum;* and the same term may not be misapplied in speaking of it as found in bulbs and tubers; but in respect of trees, shrubs, &c., a better designation will be the *vital indusium* or *envelope,* because

it covers the whole surface of the wood of these plants*.

In all cases the vital principle has the property of resisting extinction for a greater or lesser length of time: of increasing by expansion or subdivision without destruction, and by oviparous and viviparous reproduction.

Nutritive Organs.—To enable the vegetable being to subsist and perform its various functions, it is provided with organs which are recipients of aqueous or gaseous nutrition attracted from the earth and air. The fibres or spongioles of the subterranean stems, the glands and pores of the cuticle, are the chief inlets of vegetable food; and by which they receive what is proper, but by which they cannot always reject what is noxious.

The root fibres are only the recipients of the crude pabulum; this, after being introduced to the system, becomes assimilated with the inherent qualities of the plant. In vain we search the soil for qualities similar to those found in the roots, stem, leaves, and fruit; and therefore conclude that in the chambers or vessels

* It may appear somewhat problematical, or at least an unnecessary distinction, to assert that any one member of a healthily growing plant possesses more vitality than another; but such distinction is absolutely necessary in the present inquiry, as will appear in the sequel. Here also an apology may be due for the use of new terms: but as they are meant to designate a member which has been hitherto unnoticed, or confounded with others, the introduction of them on this account may be excusable.

of the plant are elaborated its essential qualities. The radicle fibre is a very delicate organ ; it appears to be elongated by protrusion of its centre. The apex is rather blunt, but a notable portion of its length is thickly beset with hair-like appendages which are probably absorbents. Fibres diverge from where they are exserted in quest of humidity, naturally receding from dry air, and turn from it whether it be above or beneath them. They are not averse to light provided it descends upon them through the medium of water or very moist air. That such fibres are only ejected in humid air, is evident from the circumstance of their never appearing on roots produced in the air, as those of *Epidēndrum*, *Pandānus*, and many other plants ; from which it may be inferred, that when such organs are destitute of fibres they are furnished with absorbent valves, or stomata, to admit nutritious fluids from the atmosphere.

The growth of fibres is simultaneous with that of the other parts of the system ; each additional shoot above requires in its development the assistance of new fibres below. But their powers and properties will be more fully adverted to when we come to describe the under-ground stems of plants.

Conducting Organs.—All vegetable structure is permeable to currents of fluids. In the lowest grade of *cellulares*, water seems to be transfusible in any direction throughout the whole mass of the plant, as we see it is in a bit of common sponge. In the higher orders of *vasculares*, the cellular frame is

diversified by numerous tubes or intercellular openings which act as conductors of the fluids whether essential or imbibed. These vessels having generally a longitudinal position, as if only intended for conveying the sap directly upwards or downwards, and though there are no very visible horizontally lying tubes, it is notwithstanding quite evident there is a lateral transfusion of the sap, probably by the divergent or convergent partitions, and by intercellular communication.

These tubes are not always surcharged with sap, some of them on this account have been called air vessels. No doubt air itself, as well as fluids of a less gross character, are necessary in the interior, as well as to the exterior of plants. Electricity is deemed one of the most effective agents in the phenomena of vegetation; and the spiral vessels found on young shoots have been considered as the special ducts for the conduction of electric currents. These are circumstances, however, which are received and credited more on the ground of their plausibility, than resting on any practical proofs which have been had of their reality.

The bark, from its suberous character and station, is well calculated for the conduction of fluids—this, the alburnum, and particularly in the space between them in the spring, we see, are the principal channels for the flow of the sap. The action of these tubular organs is greatly assisted by the proper leaves and other leafy expansions attached to the bark; even the armature, it is probable, does a like office.

Preservative Organs.—The shells of seeds, the protuberant envelope of bulbs, the pulpy mass of tubers, the bark of trees and shrubs, and the general cuticle of plants, are the preservative appendages. The coverings of seeds are various in number, texture, and durability. Some of them yield quickly to the decomposing action of the air; whilst others, defended by the horny texture—the oleaginous or resinous quality of the shell—are wonderfully persistent, whether exposed on the surface of, or buried deep in, the ground.

Bark is the common covering of trees, &c. It is composed of distinct layers of cellular matter annually detached from the vital membrane, and consequently increasing in thickness every year during the life of the tree. In some cases, however, the outer layer is thrown off when two or three years old, but in general it is persistent. The exterior layers being first deposited, they of course must gradually give way to the subsequent internal accretion of the stem, and consequently are parted into longitudinal rifts to give room to the new layers of wood and liber. There are some smooth barked trees whose annual layers of liber are remarkably thin and distensible; the first layers of which, instead of being fractured perpendicularly, are stretched horizontally, embracing the axis like a series of hoops.

The ligneous axis of a tree may be deemed a preservative member, because, though when left by the vitality, and no longer a channel for the sap, it sooner or later decays, yet before this takes places, it answers

the purpose of a prop to the branched head, and of course preserves the living parts from being laid prostrate by the winds.

Reproductive Organs.—Plants reproduce themselves by seeds, and by what are called offsets or suckers. The flowers precede and produce the former, and the vital membrane the latter. Herbs, and many trees and shrubs, extend themselves by stolones; some by the rooting of their branches which happen to touch the ground; and others there are which eject roots from their lofty branches, enter the soil, and thence throw up a new birth of stems.

The foregoing is a brief sketch of the organisation; but as all the principal organs will hereafter be described, and figured if necessary, in the order of their development, nothing farther need be added in this place.

III.—VEGETABLE LIFE.

Having endeavoured to convey ideas of the elements and organisation of vegetables, we come now to describe that phenomenon called the life, or what may be rationally deemed the causes of the motion and enlargement of these curious organised bodies.

When we reflect that vegetable matter is composed of a mass or compages of areolæ, whose membranous pellicles are extremely thin, and capable of being distended from an inconceivably small to a larger volume; and if we consider that those small cells are more or less filled with either a gaseous or aqueous constituent; and farther admit that such constituents are excitable into increased bulk by extraneous agents, we may readily conceive that enlargement of the whole mass must necessarily follow such excitement.

The primitive vesicles or cells are not visible to the keenest eye, nor, indeed, to the most powerful microscope; and when enlarged to their utmost dimensions they are, in the generality of plants, very diminutive. Even the tubes formed within the cellular body are only detectible by optical assistance. This assistance is sufficient to convince us, however, that the cells swell from a smaller to a larger size;

and if each be capable of amplification, no surprise need be felt, considering their immense numbers, at the vast productions which rise from the propago of a *Lycopērdon**, or from a seed or sucker of an *Agāve Americāna*.†

In stems and petioles of the leaves of the larger kinds of herbs, as *Mūsa*, *Crīnum*, and the like, the cells are ample, and therefore easily distinguishable by the naked eye; and the elongated cells between the joints of hollow stems, are striking instances of the expansive power of their contents, and the distensible nature of their cellular sheaths. Thus the inflation (if we may use the term) of the cells gives magnitude, and their disposition or arrangement with respect to each other, constitutes the essential character of the plant.

There are many instances of ebullition or effervescence observable in the chemical action of different bodies when mixed together, either by heat generated or applied; but such are only the effects of the common laws of attraction, repulsion &c., and are never attributed to anything like vitality; and, had vegetable growth no other properties than that of amplification, a very close resemblance might be drawn between it and the transformations, often visible in unorganised and inanimate matter.

But vegetable life has other most important and distinct properties. It is continuous, without having, in many cases, any assignable limit. Like that of

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* Puff ball. † American Aloe.

animals, it is active or dormant; in the one case constantly progressing as from the centre of a circle, diverging every way around: or, if inert, reposing safely in a kind of slumber, and imparting a conservative principle to the parts immediately surrounding it.

In seed it remains dormant, but without extinction, for ages. This is attributable to the preservative character of the coverings—its intrinsic qualities—and to the absence of those atmospheric influences, which, when present, effect the development of the plant.

Whole plants, or parts of plants, if defended from the influence of air or extreme changes of weather, may lie inert and uninjured for many months, or years; and, when replaced in a natural situation, recommence growth and exhibit every vegetable function.

From these instances it is quite obvious that vegetable life is a real, though only a *passive* principle. Real in its power of preservation even whilst asleep; and passive by virtue of its excitability, and the expansive nature of the frame in which it is contained.

Vegetable life commences and is progressive under every degree of heat between the freezing point, and 150° of Fahrenheit. It is arrested when the temperature is at or below 32°. All vegetation suffers during frost, and many plants are utterly destroyed by it. This happens in consequence of the juices becoming crystallised, by which the cells are disrupted, and the healthy organisation destroyed. Plants having an

aqueous sap are more liable to be killed by frost than those charged with a gummy or resinous juice. So those which are growing freely suffer more than such as are dormant. Some plants, as young wheat for instance, are only withered by frost, without laceration of their cellular structure; as on the return of warmth they regain their rigidity.

Extreme drought is fatal to the vitality of all plants; exhaustion of the juices by evaporation, causes an injurious shrinking of the vascular apparatus, and consequent morbosity of the organisation. Some plants are naturally defended against drought by the thick pulpy substance of their stems and leaves, such are what are called succulents: others are protected from the heat of summer by protuberant appendages of their stems; these are bulbs and tubers: and there are certain plants, which, if accidentally placed on a soil too dry for their constitution, form for themselves cellular protuberances at the base of their stems, to serve as provisional reservoirs of moisture; such is the *Phleum pratēnse.*

Although heat and moisture be absolutely necessary to vegetable development, they are of themselves inadequate to cause even the germination of seeds; because such as lie deeply buried in the earth receive no stimulus from the heat and moisture with which they are there surrounded: air and its qualities are wanting; and without which no development can take place. If seed be exposed to perfectly dry air, it receives no excitement therefrom; so that

it is only the union of heat, air, and water in due proportions, together with the influence of light, which can prompt vegetable life into perfect action.

The regermination of trees, and all the vernal movements of plants, are usually and properly ascribed to the improved temperature of the season. Yet we cannot suppose that higher temperature is the sole cause; for this reason many plants, instead of being carried along by the increasing heat of the summer, actually become torpid at the end of spring. Such are almost all our bulbs and tubers cultivated in the flower garden: and such are the first to commence a new growth in autumn, and even put forth their flowers in winter. As the precocious movements exhibited by many bulbs, tubers, and some of the amentaceous plants, cannot be attributed to increased temperature, what reason can we assign for this their seemingly premature evolution? It may be answered, that every plant is so constituted as best suits the purposes of reproduction. Bulbous, or other protuberances of the stem, are no other than safeguards to the vitality of the plant during the heat of summer; for during that time it is dormant, and continues so till the setting in of the autumnal rains, when the temperature is every day declining; so that the decreasing heat, which arrests the growth of almost all other plants, affects not bulbs. This is owing, no doubt, to the constitutional formation of the bulb, its seat of life is centrally posited, and defended by a thick investment of

old or new incrassated leaves, acting like those foliar members of buds called hybernacula. Hence the centre is sufficiently protected from the cold air, and the roots drawing nourishment from a considerable depth in the ground, progress whilst other plants, not similarly situated, are at rest. Besides, these summer sleeping plants may acquire some chemical maturation during their rest, which prepares them for instant action on the return of the temperate season.

Very differently constituted are trees and shrubs. Their vitality is not local but spread over their whole exterior, and consequently exposed to the depressing effects of cold air and frost; so also herbaceous perennials having a system of attenuated fibrous roots, and generally near the surface, are kept in check by the chilled air.

Respecting amentaceous plants, as *Cōrylus* for instance, there is no ostensible circumstance which can be said to cause the early protrusion of their male and female flowers, more than affects other plants of similar conformation and hardihood. It is true the catkins are mostly formed in the previous summer, and their winter growth is only a relaxive elongation without rigidity of sap vessels or fibres, to endanger the organisation by frost; indeed flowering, at this *dark season*, is one of those wise provisions of nature which excites our admiration, for assuredly were such delicate and attenuated bodies exposed to the withering winds and sunshine of the month of March, they would be quickly destroyed before the pollen

could be ripened and dispersed. We have also instances of many *Icosandrious* plants whose stamina are extremely delicate, and which flower early in spring. May this not be attributed to a law of nature, which, by bringing out the flowers early, secures them from the effects of ardent sunshine? The night-flowering *Cereus* is a remarkable instance of flowers of attenuated structure shunning the scorching effects of the sun.

Vegetable life exists in a twofold state, viz. that in which it is dormant, as has already been alluded to, and that in which it is actively swelling the cellular apparatus containing it into greater volume. The wood and inner layers of bark are said to be alive so long as they share any of the rising sap, or act organically in its conduction, notwithstanding the actual vitality has long left them. The living principle is always found between the wood and liber. It is, we are led to imagine, a distinct member of the plant; and as such will be described, when the other members of the system come under review. Suffice it to add here, that this member is the fountain of life and organisation; and so long as it remains possessed of its essential sap, it is capable of expansion and reproduction of every constitutional member of the plant.

Besides the swelling motion of vegetables there are other motions, which may be called accidental and extraordinary. Accidental motions are those occasioned by the state of the soil or weather. When

either is too dry, the leaves and shoots become flaccid and droop from their natural position; but when humid air or water is restored to the plant, the flaccid parts recover their rigidity and position: such movements are easily accounted for. Other motions are produced by the action of heat and light, which have the effect of expanding flowers and foliage: but, being withdrawn, they relapse to a state of repose, which is called their sleep. The pedicels of some flowers, as *Convolvulus*, are erect or horizontal while in bloom, but immediately turn downward to ripen the seed. Extraordinary motions are those of the pinnulæ of *Desmodium gyrans* *; the collapsing of the leaflets of *Dionæa* †, and *Mimosa* ‡, the elastic action of the stamens of *Bĕrberis* §, and that of the petals of some of the *Orchideæ* ‖. All these spontaneous motions are wonderful; and cannot be rationally accounted for from any knowledge we possess of the articulations which become so suddenly and alternately lax and rigid.

These instances sufficiently prove that plants are sensitive and irritable; whence some philosophers have come to the conclusion, that they are actually endowed with muscles, a system of nerves, and not only recede from the contact of animals, but, moreover, are conscious of pleasure and pain! It is certain that the appearance of a healthy plant soon after the morning sun shines upon it, and while "spreading its enamoured bosom to his ray," in some measure jus-

* Moving plant. † Fly-trap. ‡ Sensitive plant. § Berberry. ‖ Orchis.

tifies this idea; and it cannot be denied, that the effects of genial warmth and light are as fully felt and enjoyed by vegetables as by animals.

The constitutional sensitiveness of plants is also evinced by the branches of a tree planted near a wall turning away from, before reaching, it; and also all growth tending to the strongest light is in both cases attributed to the attraction of, or the tendency of vegetation to, that body, whether solar or ignescent*. The tendency of radical fibres extending themselves towards heat, moisture, or rich food, is also curious; and can only be explained by ascribing it to the law of attraction, because all bodies, which mutually attract each other, form between themselves a current of their fluids; and thus, while streaming towards the recipient, induce the protrusion of the spongioles of the latter to meet it—hence their elongation.

From all these circumstances, we may rationally conclude that, notwithstanding much of the phenomena of vegetation may be traced to combined chemical and physical action, we must admit the existence of a vital principle, which seems independent thereof; more especially in its power of existing for ages unimpaired in the bowels of the earth; and, while thus dormant, may be best defined by the remark, that vegetable life is an *excitable* or *fermentative* fluid, contained in an organised *expansible* body.

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* The flower of the *Crocus* may be opened by candle-light: and also by fire-heat, though partially shaded.

DISTINCTIONS OF VEGETABLES.

The vegetable kingdom is naturally divided, according to some old botanists, into four divisions, namely, trees, shrubs, herbs, and what may be called terrene plants. Recently published lists enumerate above one hundred thousand in the whole: comprising 3416 genera; above 32,000 species; with varieties and sub-varieties innumerable!

For the facility of studying, identifying, and describing this vast assemblage of vegetable productions, botanists have arranged it into

Divisions, founded on the elemental structure, viz. vasculares and cellulares.

Classes, on the number of the cotyledons or seminal leaves, as respects monocotyledones and dicotyledones, and on the want of, or presence of, foliaceous structure in the plants of acotyledones.

Sub-divisions, on the calyx and corolla being, or not being distinct.

Sub-classes, on the situation of the stamens.

Orders, on the most prevailing character.

Tribes, on near alliances.

Genera, on ancient and modern names and characters.

Species, on individual character.

The further illustration of this, or any other systematic arrangement of plants, is not intended in these essays, here it would be superfluous, seeing there are already so many excellent books on the subject. But by taking a general view of the vegetable kingdom, opportunity will be afforded to mark the physical structure, notice the organic functions, and describe the manner of development of the various plants which differ most from each other in constitutional character and appearance.

The elementary structure and organisation have been already adverted to, and which sufficiently mark the distinguishing characteristics of Jussieu's two grand divisions: we may next notice the peculiarities of development which identify the classes of his natural arrangement: viz.

Acotyledones.—Are plants which rise destitute of visible seed-leaves. Linnæus long ago noticed the evident difference there is between the first foliar expansions (when there are any such) of his *Cryptogamia* and those of the more perfect plants; conceiving the seedlings of the former to be more like viviparous than oviparous progeny: hence he called them *propagines.* The seed-leaves of the cryptogamous *Foliàceæ* being similar in structure and appearance to all that follow, and the whole plant being mostly of a cellular and uniform texture, the distinction is obvious. We say mostly, because Jussieu himself admits, that some of the *Filices* are partly vascular, though without spiral vessels.

It may be observed of this class, that in all probability future botanists may find it necessary to remove some of the genera now included in it: already it has been discovered that the first expanded member of a fern is different from the succeeding leaves; consequently, if this be not a mistake, they should be removed to the second class: and as a great majority of *acotyledoneæ* have very small seeds, if seeds they may be called, their evolved parts are extremely minute, a circumstance which renders their classification a task of some difficulty.

Monocotyledones.—Are such plants as rise with only one seed-leaf. There is some obscurity about this characteristic distinction. The first foliole or member, called the cotyledon, is so much like the perfect leaves in shape and texture, though not in size, that there is room for doubt. If we take *Pancrătium* and *Cōcos* as examples, it appears that the first leaves of these plants are in fact real leaves, and not cotyledons. The infant plant is nourished for some considerable time by the albumen or kernel of the seed, and, therefore, *unexpanded cotyledons* would have been perhaps the most accurate distinction.

Dicotyledones.—Are plants furnished with two or more seminal leaves, and which are expanded in the air, as *Brăssica* *, or under the surface of the ground, as *Făba* †.

The annexed figures represent the germination of the classes.

* Cabbage. † Garden bean.

Fig. 6.

Acotyledoneæ.
Conferva.

Fig. 7.

Monocotyledoneæ.
Cocos.

Fig. 8

Dicotyledoneæ.
Sinapis.

These are the divisions and classes under which the vegetable kingdom is arranged by the celebrated Jussieu, and as improved by the no less celebrated De Candolle. Its excellence as a system consists in its being founded on the most remarkable and obvious distinctions observable in nature, namely—in elemental structure, in the components of the seed, in the arrangement of the floral appendages, on affinity in resemblance and essential qualities, and on general character. It is very probable that its author conceived, at the outset, his scheme would not only simplify, but greatly compress the science into narrower bounds, and thereby enable the student to grasp the whole with but little application. But this, if ever expected, has not been verified; for such is the diversity of vegetable forms and qualities, that the system has become in his own and followers' hands, so very complex and diffuse, that the orders,

sub-orders, sections, and alliances, are so multiplied and multiplying to such an interminable extent, that it is in some degree discouraging to the student, as well as to *some* practical botanists. Still the outlines and striking characteristics of the divisions, classes, and major part of the orders are so truly natural and satisfactory, that it is certainly a pleasant and interesting treat to be led through the labyrinths of vegetation by such a master; though it may be safely predicted, that it is reserved for some future disciple to re-arrange the Jussieuan system: who by disregarding minor distinctions, doubtful alliances, and mere shades of physical difference, may render the whole both more simple and concise.

SECTION I.—ACOTYLEDONEÆ.

In the following review we may repeat that it is only the more ostensible features of the system which are intended to be noticed; short descriptions, and figures when necessary, will accomplish what is proposed, viz. to give a plain survey of the physical constitution of plants. In order to this it will be expedient to begin with the lowest grade, viz.

Fungi.—The microscope has very much extended our knowledge of many minute plants which would for ever have escaped the naked eye; and it may be presumed, that numbers still remain unknown, not only on the surface of the earth and on various mine-

ral, vegetable, and animal substances, but actually within them. However close the texture of rocks and stones, vegetation attaches itself to them. The discolorations or weather stains on these and on buildings are caused by the presence of *Lichens*, *Confervæ*, &c.; and wood of all kinds is the habitat of numerous *Fungi*. These last not only exist on the exterior, but penetrate and even decompose the hardest timber. The dry-rot appears to be no other than the seizure and destruction of a fungus*; and from

* Whether the dry-rot, *Merulius destrùens* be the cause, or only the effect of decay in timber is a point not yet sufficiently ascertained by naturalists. As many of the congeners of this plant affect rotten vegetable substances, it is quite natural to suppose that decay precedes the attack of the fungus, and therefore the conclusion is, that timber so destroyed, must have been either imperfectly seasoned, or laid in a place deficient of due ventilation. It is well known that the basement timbers of buildings are more liable to dry-rot, than those on the upper stories, and that if oil-cloth or other covering impenetrable to air and moisture lie long unmoved in the same place, dry-rot will appear sooner or later in the boards beneath; showing decidedly, that in such cases, want of free air invites *merulius*. But to what can we impute the decomposition of the massive ribs of a ship of war, while yet on the stocks, and before being either planked or sheathed, and exposed to full and dry air for two or three years? Here there is neither oil cloth or paint to shut in sap that might be detrimental; on the contrary, every precaution is taken that the scantling be perfectly seasoned. Still before the ship is launched, these timbers, though apparently sound and perfect to the eye, are found defective—the interior being only a mass of dust. If we examine its progress we shall see that the sound wood is divided from the unsound by a very slender line; and that the fibrous tissue of the plant appears to absorb the juice and decompose the cellular structure of the wood.

the progress of this plant, as well as that of common cultivated mushroom, there is reason to suspect that like all other plants developed in the air, they are composed of various members, viz. roots, branches, and fructification, the latter only appearing on the surface.

It is perfectly true that, on examination of the mushroom plant, there appears only a system of root-like fibres and the fructification; but as these fibres spread themselves to a considerable distance round their first station, and bear the edible part on their extremities, we must either consider them real branches, or, if roots, that they are capable of bearing fruit*, a circumstance which has no parallel in the vegetable kingdom. Inferior tribes of plants which inhabit the depths of the ocean, lakes, and rivers, are composed of various organs, as roots, stems, &c., and why may not such as the *Fungi* be similarly organised? Among the latter, however, there is at least one exception, namely, *Tuber* (the *Truffle*) which is decidedly subterranean and apparently destitute of any other parts than an irregularly globose tuber, without visible stem or branches: whence a few slender fibres only are exserted. How the tuber is reproduced remains a mystery; whether by inconspicuous sexual organs or by viviparous subdivision is not ascertained, any further than that very small tubers are found near the larger.

* It may sound uncouthly to call a mushroom a fruit, but it is as proper to call it so as it is to call the pulp of an apple the fruit.

The whole division *Acotyledoneæ* is no less remarkable in habitat than obscure in the manner of reproduction. The plants included in it are in duration. ephemeral, annual, or perennial; in form filaceous or foliaceous; in consistence, carnose, coriaceous, membranaceous, crustaceous, fibrous, or gelatinous; in station they are found rooted in earth, adhering to rocks and stones, or as parasites on other plants; existing chiefly in cold humid regions either in the open air, floating on, or constantly submerged in water; from the motion of which they are, like aquatic animals, defended by a mucus, acting instead of a cuticle, covering their whole exterior. But of whatever form or magnitude they may be, their elementary structure, with but few exceptions, is cellular. The most simple of this division is, perhaps, the *Tremēlla*; it being only a formless body of jelly, bearing, even in its most mature state, very slight marks of organisation. The most complicated and perfect plants are contained in the class *Foliaceæ*, viz. the *Equisitāceæ*, and the *Fīlices:* some of the latter arrive at a considerable and tree-like size, and are most elegant in their forms, and curious in their evolution.

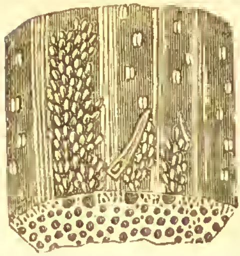
Many of the ferns have tuberous stems which are perennial, and reptant either beneath or on the surface of the ground. The fine powder discharged from the fronds, if not seed, is certainly a vital essence; as plants are easily raised by sowing it on a proper soil and in a favourable situation. And of its tena-

city of life, it may be observed as proof, that plants have been raised from the dust of specimens after being kept in a *hortus siccus* for a period of forty years.

The fine dust discharged by the *Fungi* is also, no doubt, the seminal produce ; because, how else can it be so generally distributed as we find it to be in the case of the common mushroom ? In the cultivation of this fungus we generally keep fragments of the plant itself under the name of spawn; but it is well known that the mushroom may be generated by merely collecting substances which are known to be affected by the plant. These put together in a dry place, and applying to the mass a moderate degree of artificial heat, the seeds of the mushroom accidentally therein are developed, and the perfect plant with its edible part obtained. This fact is so constantly before our eyes that specific modes of cultivation are founded on it, and, being attended with success, leave no doubt of the idea, that the light and almost impalpable dust of the mushroom is, in fact, real seed; which is wafted around by the winds, and wherever deposited under favourable circumstances, germinates and comes to perfection.

There are many microscopic species of *Fungi* which are only discoverable by their effects. One of the most destructive is the rust or blight in wheat and other cereals.

Fig. 9.



Pucinia graminis on the straw of wheat.

Its prevalence in some seasons, can only be accounted for by supposing, that the seeds are conveyed from the perfect plants by the wind, and, lodging in the pores or cells or cuticle of the straw, vegetate and come to maturity. It is remarked of the *Fungi*, as well as of many of the other orders, that they affect peculiar substances as their habitat. Some are only met with on particular kinds of dead or dying trees; many luxuriate on the bark, others on decayed roots, and several occupy the solid timber in the various stages of its decomposition. Many attach themselves to particular kinds of rock or earth, whilst others prefer the leaves of living plants.

The growth of this division takes place by the inflation of the cellular structure; commencing, as before observed, at a little distance from the centre, and proceeding outwards, Fig. 5. Whether the substance be carnose, membranaceous, or foliaceous, the exterior is invariably covered with a dense film or cuticle, which in many cases parts readily from the

interior mass. Hardly any of these plants appear to have any definite magnitude; individuals of the same species being very different in size: the common mushroom, we see, varies from one inch to one foot in diameter.

Many of the acotyledones are evanescent and quickly perishable in the open air; yet, when dried and kept free from moisture, the lichens and fungi change to a leathery consistence, and then are very durable. Individuals of almost all the orders are used as articles of diet in the arts or materia medica.

Some of this class are remarkable for their tenacity of life. Several of the mosses after being kept in cabinets, as specimens or otherwise, for many years, and in which time they have become completely dried, nevertheless, as soon as they are exposed to moist air, recover vitality, and grow again as well as ever.

SECTION II. MONOCOTYLEDONEÆ.

LEAVING the acotyledoneæ, we now enter on the most simple order of the monocotyledoneæ, namely, the *Gramineæ**. In all moist and temperate climates these form the general covering of the earth. They furnish man with the "staff of life," and for the herds and flocks of our depasturing animals are the most useful of all others.

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* Grasses.

The structure of the grasses is extremely simple; consisting of fibrous roots issuing from a flattened crown or collet, whence spring hollow or solid jointed stems—linear leaves borne on the joints of the stem, which latter bear a terminal spike or panicle of perfect or phænogamous flowers and seed.

In duration they are either annual, as *Hōrdeum vulgare;* biennial, as *Brōmus tectōrum;* or perennial, as *Dāctylus glomerāta.* Some are minute herbs, forming a thick turf; others are arborescent, rising to the height of many feet; mostly stoloniferous, by which they are increased as well as by seed.

The physical structure, vital powers, and manner of development, may be described as follows, viz:—

The seed is covered by a husk of cellular tissue, inclosing a farinaceous albumen which contains the corculum or embryo plant. The embryo, as in all other cases, is composed of two principles, viz. the rostellum from which the radicle fibres are exserted, and the plumula, which rises in the air. Both proceed from the base of the seed; the first leaf hourly increasing in height, and succeeded by others evolved from within it; in fact the first leaf evolves all the others, together with the stem and fructification.

Botanists are not agreed which member of the infant plant is the true cotyledon. At the base of each stem there is a small scale-like substance called the *vitellus*, and immediately above this there is a delicate sheath embracing the incipient leaves and stem, and through which they come forth. The latter

is considered the true cotyledon by some authors; while others deem the former the true one, in order to be consistent with the characteristic title of the class. Be this as it may, it is certain neither do the imputed office of cotyledons; that being performed by the albumen, which yields the nourishment necessary for the young plant till the radicles have established themselves in the soil.

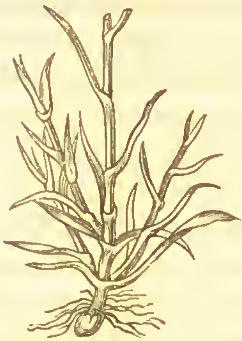
The corculum, that is, the body whence the roots and stem originate, is a compound organ, consisting of the rudiments of many sets of roots, and of many culms. Each joint of the culms is constituted like the corculum, i. e., it is capable of producing both roots and new sets of shoots, if placed in favouring circumstances. Whether a single grain (of wheat for instance) throws up one or ten culms, depends entirely on the fertility of the soil, favourable season, or space allowed it to grow in; consequently, the wheat plant is capable of repeated division and subdivision by art to any extent during the spring months; showing that the corculum is an aggregation of vital essences which are developed either singly or collectively.

The following figures are illustrative of the foregoing description, and may be considered as types of the germination and constitution of the *Gramineæ* in general, whether annual or perennial.

Fig. 10.

Germination of Barley.

Fig. 11.



Germination of Wheat.

Fig. 12.

Development of perennial Gramineæ.

The culms are incipiently depressed cones; in this state they exist, no doubt, even in the seed. Those of wheat generally consist of eight joints; the first and second at the bottom, if the grain has been deposited at the proper depth, are short, every higher one increasing in length—the last bearing the ear being the longest. The culms progress in height by the inflation and perpendicular extension of the large cells occupying the centre between the joints, and of the denser cellular tissue composing the exterior cylinder. The latter is also inflated horizontally; its inner side becoming vascular, and forming the principal channel for the ascent of the sap. The exterior surface of the stem is somewhat fluted, dense,

and pierced at pretty regular distances by some of the horizontally lying cells, Fig. 9, forming stomata or openings for the emission or admission of aërial fluids. The exterior is also in some cases remarkably smooth and glossy, and ultimately becomes membranous, i. e. dense cellular matter and of considerable tenacity.

It is from the compound character of the corculum or crown of these plants, that, under favourable circumstances of soil and season, the annual species are so productive of thick and heavy crops. On very inferior land a seed may only bring a single culm and ear to perfection, whilst on rich land from seven to twenty is the usual produce. From the same circumstance it is, that the perennial species spread themselves on the surface and form so thick a turf. In both cases this property may be excited by the operation of the sithe or close-grazing animals preventing the seeding of the plants. Such mutilation, frequently repeated, even changes the nature of some species so much, that annuals become biennials, and biennials almost perennial in duration; and this merely from denying them the principal aim of their being, the production of seed.

There is another kind of mutilation which increases the volume and produce of grasses; it has been already observed, that each culm has its own system of roots, but which remain inert if the culm itself be not called into action; when, however, the primary productions are cut, eaten over, or trampled

down, the secondary offsets immediately come forth in greater numbers and strength than if the first developed parts of the plant had sustained no injury. Hence the propriety of eating down rank crops of wheat, mowing thin crops of grass, and drag-harrowing old meadows.

Next in value to those *Gramineæ* which yield the most nutritious food and drink to man, and pasturage to our herds, ranks the *Saccharum officinale*, or sugar-cane, so universally employed as an article in diet, and many other purposes of human life. It is a perennial, having the same structure and vital powers as the other grasses, only of a more robust habit and greater magnitude. But the most majestic in size is the *Bambūsa arundinācea*. This plant throws up a thicket of arborescent culms, which rise to the height of forty feet, or even more, annually increasing in number, and extending from the first station. The culms, though so herbaceous when they first issue from the ground as to be cut like asparagus and used green as a pickle, become at last perfectly ligneous, and so exceedingly compact, elastic, and durable, that, for the construction of Indian cabins, implements, and household furniture, the bamboo excels all other kinds of wood.

Cārices et Junceæ.—Next to the grasses are ranked these generally worthless tribes. Their physical structure is rather more complex than the preceding, having a few more members in the flowers. They are mostly inhabitants of barren ground, the

sea-shore, borders of lakes and streams, and in pools of stagnant water. Some few have showy flowers: but in general they are rigid herbs, fit only for the purpose of the door-mat and chair maker. The larger rushes, it is well known, have a large vascular pith, which, when divested of the cuticle, is used as wicks for candles.

Arums, and their alliances, are the next grade of herbaceous plants. They have mostly tuberous subterranean stems, or thick fleshy roots, many of which are edible. The *A. Indicum* (?) is extensively cultivated in China for its tubers, which, with those of the water lily, form the bulk of such kind of culinary vegetables in the markets at Canton. The leaves of the *Caladium esculentum* are used as spinach in India; but in general the leaves of this tribe of plants contain a bitter principle, which renders them unsavoury and sometimes dangerous. Passing these comparatively humble herbs, together with the rest of the *Aroideæ*, we next come to the conspicuous.

Pandaneæ and *Palmæ*.—These two orders, though nearly allied to each other, are very different in their constitutional conformation: the former being divisible, naturally by off-sets, and artificially by cuttings, the latter not. The mode of rooting of some of the *Pandaneæ* is remarkable. The growth is continued in grades. Each successive expansion of leaves and stem is accompanied by an additional number of roots, which are produced not from the original

collet, but from the articulations of the stem above. The first roots are only attached to, and specially connected with, the base of the stem; the superior part of it is supported by monstrous fibres issuing from the joints, which descend and fix themselves in the ground, acting like buttresses to the weighty head. During the descent of these large roots, it is quite evident that they are prolonged by the protrusion of their central parts; and, what is very remarkable, thin films of cellular matter, similar to the sheaths on the young roots of *Cruciferæ*, or like the liber of other plants, are frequently discharged from the point, like cups one within another, acting, before they fall off, like reservoirs of water for the sustentation of the tender point. This peculiarity was first brought to our notice by our intelligent friends, Messrs. Loddiges, of Hackney.

The majestic tribe of palms occupies the middle station between herbs and what are properly called trees. Like the latter, they rise to a great height on a regular columnar stem, which, though herbaceous at first, afterwards becomes ligneous; but, like some other plants, they have at all times only a single tuft of leaves, without branches or other division of the axis.

Some of the palms, it is said, present the extraordinary spectacle of being *individual* plants, possessing but one vital essence, incapable of division, either by the roots, parts of the stem, or in any way save by seed; which, when it has produced, the

whole dies. Such are only temporary beings, and are those in which the fructification is terminal and solitary. No latent gems are seated in the roots or stem; nor are there branches or buds. The growth is a continuous procession from the seed to the ripening of the fruit, the leaves being developed in succession. The bases of the petioles are articulated* with the axis, but are very persistingly united to each other, and aggregately form the exterior of the stem in the early stage of its growth. Hence it appears that the seedling palm is composed of roots which take a potent hold of the soil; a thick investment of many, probably a certain number of leaves, enclosing the fructification in their centre. As the growth advances the exterior leaves are first expanded, followed by the next within, and so progressively till the last, evolving the spatha, is developed. During all this time the fructification is gradually rising and keeping pace with, but always some distance below, the tufts of fronds, till it nearly gains the summit, when, on the parting of the last leaves, the spatha, containing the fructification, comes forth, and bending with its own weight hangs gracefully below the foot-stalks of the leaves, where

* From the appearance of the *Phœnix*, *Cocus*, and several other palms in India, it is not evident that the fronds articulate with the stem; but it is affirmed by some botanists, that, after a long period of time, their bases at last fall off and leave the stem smooth and regularly scarred like the *Bambusa*.

it flowers and ripens its fruit. If it be a sort whose flowers are terminal, the maturation of the fruit is the termination of the life of the plant. But the generality of palms exsert their flowers laterally from the axillæ of the fronds, the latter being continually produced from the centre of the stem, succeeding each other for a long series of years. Here it may be observed, that the palms, and all such constituted plants, gain altitude and diameter of stem by the progressive evolution of the leaves which rise from the interior: of course the body of the stem is enlarged by accretions or expansions within, not by concentric layers of ligneous matter on the exterior, as is the case with dicotyledonous shrubs and trees. The stem is, therefore, uniform in arrangement, composed of strong membranous fibres, embedded in suberous cellular matter, and without a distinct bark. Some of the palms have a notable pith, which may be separated from the fibres which surround and exist in it, and manufactured into a granular substance, commonly used as an article of diet by the natives of India.

The common beverage of the inhabitants of Coromandel, called toddy, is drawn from the *Cōcos* and some other palms, and obtained thus:—as soon as the spadix turns downward its point is cut off, and from the wound flows the liquor, which is caught in pitchers slung to the stump. Thus collected, it is put together in a large vessel where it is allowed to ferment for a short time, when it is fit for use. This liquor is

subacid, cooling, and somewhat exhilarating, though not so as to inebriate. A strong spirit is also drawn from the toddy by distillation. The outer covering or husk of the cocoa nut, after being macerated in water, and beaten to discharge the cellular pulp, yields a coarse filaceous substance, of which mats, cordage, and even ships' cables are made; and the kernel yields what are called milk, cream, and an abundance of useful oil. The wood of the *Cŏcos* and other palms, though of extremely coarse grain, is very durable, and much used in buildings and fences. The leaves or fronds, too, make excellent thatch.

The date tree, *Phœnix dactylifera*, is a valuable fruit tree, as well for the use of the inhabitants where it grows, as an article of commerce. The *Latania barbonica* is said to be the most magnificent vegetable in nature.

The next grades requiring notice are in structure more complex, though much more humble in stature, than the preceding. Among the *Bromeliăceæ*, the *Ananăssa*, or cultivated pine apple, may be chosen as a type. They are mostly suffruticose plants, the stem acquiring a woody consistence, though their general colour and appearance is decidedly herbaceous. The roots are thick fibres issuing first from the bottom of the stem, but subsequently and periodically in sets from the joints above, during the life of the plant. Each joint is organised like the original crown; in fact they appear to be only detachments of it, as they

produce roots and branches, and those again other roots and branches, for ever.

The stem of this plant in its wild state rises from two to three feet high or more, bearing the fruit on the upper part of the stem, yielding both oviparous and viviparous progeny, as well as suckers from the lower joints while the fruit is ripening. Soon as this is matured it falls to the ground, and at the same time the stem that supported, and the system of roots which perfected it, die also; but the suckers by this time being well rooted, progress, and produce their fruit and successive progeny in all directions around. This is the case with all plants of similar conformation; as the *Agūve Americūna,* some sorts of *Sempervivum*, and many others.

The following are sketches of the pine apple plant in different stages of its growth.

Fig. 13.

A young pine apple plant.

Fig. 14.

Perfect form of the pine apple plant.

Fig. 15.

Manner of the last year's suckers fruiting, after the principal is dead.

It may be observed of the *Ananūssa*, *Pandāneæ*, and all other plants of similar structure, that the future growth depends more on roots which are to be produced, than on those already in existence; every new whorl of leaves being perfected by roots simultaneously exserted. It is this circumstance which allows entire disrooting with impunity when necessary in their cultivation.

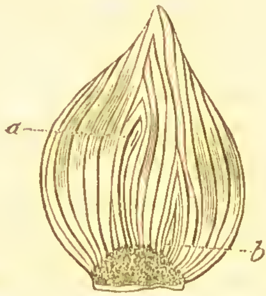
We now approach the liliaceous tribes. They are chiefly bulbous and tuberous stemmed plants, and as varied in form and constitutional structure as their flowers are splendid. The *Melanthūceæ* and *Amaryllīdeæ*, with the intermediate orders, compose the group of herbaceous plants now to be noticed.

Taking the tulip as a type of the bulbous stemmed plants, it may be described in its perennial character as being constitutionally composed of an indefinite assemblage of vital entities, each of which is a perfect plant, consisting of fibrous roots, leaves, stem, flower, and seed, and which when, the last is ripe, wholly dies. This assemblage of gems* are seated and crowded together on or in what is called "the radicle plate," which appears to be constituted like the ovary of an animal, whence they are successively developed, either in the order of their seniority or of their position. The highest or oldest of the train developed this year, is succeeded by the second

* Gems or germs, terms used to express the latent or invisible principles of buds or flowers.

of their series in the next, and so on, barring accidents, for ever.

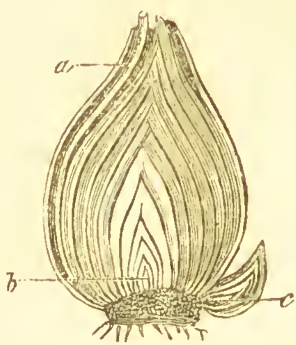
Fig. 16.



Section of a tulip bulb in autumn :—*a*, the flower of the following spring; *b*, the succeeding division of the bulb which is perfected during the summer.

It sometimes happens, that two or more of the senior members come forth in the same season, and either advance to flower or are detached laterally as offsets, which may be separated without injury to the remaining body of incipient gems.

Fig. 17.



Section of a tulip bulb immediately after flowering :—*a*, part of the scape pressed to the exterior by the succession division; *b*, *c*, an offset produced during summer.

This property of the tulip producing both seeds and offsets at the same time is common to many other plants; and caused by an extra vigour, derived from favourable circumstances of soil or situation. These different powers of reproduction are reciprocally dependent on each other. If the seeds be fully and perfectly matured, few or no offsets are produced, and should the flower fail or be destroyed, an extraordinary number of offsets are put forth.

The radicle plate is a depressed cone of dense cellular matter in which the incipient gems lie invisibly embedded. It always appears as the base of the largest division of the bulb, and the nucleus or source whence all gems, whether primary or secondary, successively issue, without any notable diminution thereof. Under a common microscope its substance is uniform; not visibly granular, as might be expected; the parts composing it being so blended together that they cannot be distinguished till they are resolved into principals or discharged as offsets. From its under surface, and particularly from the edges, the roots come forth; appearing to belong only to the superior gem which is in the act of expansion; because, as observed above, they are exserted and decay together. The next year's gem is furnished with roots of its own, and has no dependence on those of its predecessor, they being very attenuated, and only annual.

The leaves of the tulip are comparatively few in number: some of the outer range are short, incras-

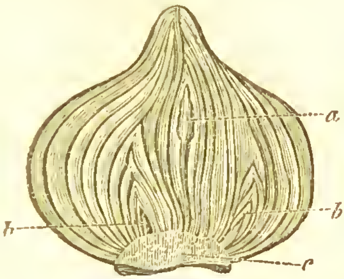
sated, and but little elongated during the growth; but the inner ones, partly attached to the scape, rise therewith and gain considerable amplitude. The scape, flower, &c., need no description.

It does not appear that there is any definite limit to the number of vital essences contained in the radicle plate; it is only destructible by insects, too much moisture, or extremes of temperature. So long, therefore, as it remains uninjured, so long is it capable of producing perfect progeny. Even if kept in a place where the senior gem cannot be developed, the radicle plate can, from its inherent energy, send forth numerous offsets, without the assistance of leaves or any other superior member of the system. Thus the tulip is a perennial by the succession of individual parts rising seriatim for an indefinite length of time.

The hyacinth is constituted like the tulip, and produces seeds and offsets in a similar manner; only the first abbreviated leaves, which form the exterior of the bulb, are more persistent, withering imperceptibly, and consequently have a more permanent character; these appear to have an identity from one season to another, which they really have not, for every bulb undergoes a positive transformation internally, inasmuch as a new gem, to flower next year, is swelled into volume as the successor of that which has flowered in this. The full-grown hyacinth bulb, as well as those of the polyanthus narcissus, are always larger than the tulip, owing to

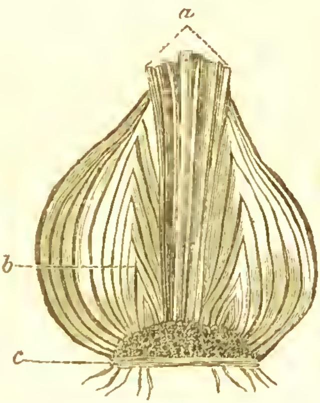
the succession gems of the two former beginning their growth at an earlier period before flowering than do those of the latter. Figs. 18, 19, and 20.

Fig. 18.



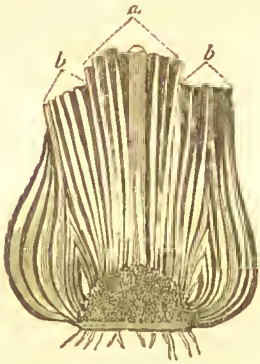
Section of a hyacinth bulb in autumn:—*a*, the flower perfected in the spring; *b*, *b*, two succession divisions advancing into form; *c*, the radicle plate.

Fig. 19.



Section of a hyacinth after flowering:—*a*, scape and leaves that rose therewith; *b*, next succeeding division; *c*, radicle plate and roots.

Fig. 20.



Section of a polyanthus narcissus after flowering:—*a*, scape and accompanying leaves; *b*, *b*, leaves of the succeeding divisions which have not yet flowered.

But there are various modifications of bulbs: the leaves of *Allium pŏrrum**, and *Agapănthus umbellātus*†, are but slightly incrassated at the base; the *Allium Cēpa*‡ is peculiar in having cylindrical hollow leaves; consequently the tunics of the bulb are entire, except a lateral slit through which each interior leaf protrudes through the exterior one which involves it. The gouty stems of the *Pancrătium* and *Crīnum* can hardly be ranked as bulbs, because the protuberant investment at the base is only the vestige of former leaves, which have a permanent character for the protection of the stem.

Besides these differences, there is another remarkable structure of the bulb which deserves the attention of physiologists. Some, as the tulip and hyacinth, have their flowers terminal; when these are expanded

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* Common leek. † Blue African lily. ‡ Onion.

and the seed perfected, they, together with the leaves, bulb, and roots of this section of the plant, are shed, and separated by decay, Fig. 17. But it is not so with such as the *Agapānthus*, the *Eucōmis*, and many, if not all, of the *Amaryllideæ**. These last mentioned, instead of flowers, have their foliage terminal; the flowers being produced laterally from the axillæ of former leaves, so that the bulbous body of the stem is constituted very differently from those of the first-mentioned plants.

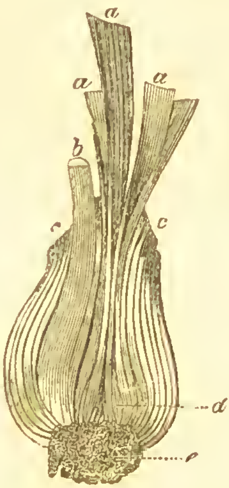
It may be remarked in this place, that, with respect to the term bulb, it is, perhaps, necessary it should be retained, as it is now in commerce; but botanists would do well to make a proper distinction between bulbs and those improperly so called, which are really tubers. The former term should be confined to those plants which have their collet or radicle plate defended by abbreviated leaves, and consequently have *tunicated* bulbs. All others having an incrassated stem of a globose form, and not composed of distinct laminæ, but a solid body of farinaceous or pulpy cellular matter, and which exsert flowers from the sides as well as the apex, are properly tubers, and should be designated as such.

The *Amaryllīdeæ* seem to partake of the conformation of both bulb and tuber; for, in comparing them with that of the tulip, we find that they both have a radicle plate or collet whence all the growth originates; their bulbs are both formed of new or the

* Lilies.

remains of old leaves; but they are unlike in this particular,—that whereas the tulip throws off annually detachments of root, leaves, and flowers, to be expanded and perish, the amaryllis in its flowering is not so dismembered; the leaves and roots being exserted at one time and the flower at another, the two former preceding the latter. Hence it appears, that the leaves and flowers of the amaryllis are separately posited in the bulb; or, if connected like those of the tulip, they do not come forth together. Fig. 21 is a section of a bulb of the *Amaryllis vittàta*, immediately after flowering, showing the attachment of the old scape, and the place whence the next flower proceeds.

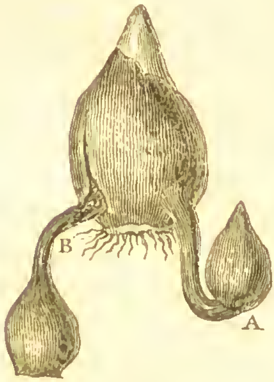
Fig. 21.



a, *a*, *a*, central leaves; *b*, part of the scape to show its attachment to the radicle plate; *c*, *c*, remains of former leaves; *d*, the next succession flower: *e*, the radicle plate.

The foregoing description of the physical constitution of bulbous stems will be found generally correct; but that they are occasionally subject to aberrations of growth is very manifest. It has been assumed that the radicle collet of a bulb is for the most part stationary, increasing in bulk, or annually divided by the development of parts of itself in a peculiar manner, as has already been noticed in treating of the tulip, &c. But sometimes irregularities occur, either from the bulb being misplaced in the ground, from a wound, or from peculiar excitement; because we meet with bulbs, especially of those having double flowers, that are irregularly formed, and producing monstrosities which are exceptions to the rule previously explained. We have now before us two tulip bulbs, one of which, instead of being increased in the usual way, (Fig. 17,) is elongated, as in Fig. 22, in order that a detachment of the collet may take a deeper station in the soil; so that in its future growth, the increase of new offsets and roots, will be from the point A. fig. 22, instead of, or as well as, from the point B. We have also a hyacinth bulb elongated downward in the same manner; and it is well known, that offsets from the tulip, *Lachenàlia*, and *Hæmànthus* often appear among and even on, the bases of the fractured leaves of these plants. These instances only go to prove that though nature be generally uniform in her processes, she will, under the expedients of cultivation, become subject to variations which are purely accidental.

Fig. 22.



It is further worthy of remark concerning the constitution of the radicle plate or collet of bulbs, that its vitality is such, that if parts of it be detached they will produce new bulbs. And in some species, even the scales, or parts of them, will be formed into new plants if placed in favourable circumstances. If the scape of a narcissus be pulled out from among the leaves, having a part of the radicle plate attached, and planted in the soil, it will continue to live and form bulbs for itself.

Among the orders *Melanthàceæ*, *Tulipāceæ*, and *Asphodēleæ* there are many whose protuberant stems are so constituted as to make it difficult to determine whether they should be designated bulbs or tubers; so that the modern term *bulbous tuber* is quite appropriate. The white and orange lilies are called squamose bulbs; and though they resemble bulbs in

having an exterior investment of incrassated, stationary leaves, yet the flower stem rising not always from the same place, shows that they possess one property of the true tuber. Some species of the lily reproduce themselves by gems ejected from the axillæ of the leaves, which have all the parts and powers of bulbs or seed.

Among the *Asphodēleæ* we find the favourite vegetable delicacy *Asparagus*. It may be called a much divided tuberous root; the divisions united in a compound crown, whence the stems rise in succession. Offsets having a short pedicle or runner, are detached periodically, and generally in one direction, from the first station; the oldest divisions of the crown dying off as young ones are produced.

Fig. 23.

The roots of Asparagus, showing the manner of increase.

Tuberous-stemmed plants are such as have their collet surrounded, not by bracteous-like leaves, but by, as before observed, a large body of pulpy, or farinaceous, or ligneous cellular matter; on the exterior of which the gems producing leaves, stems,

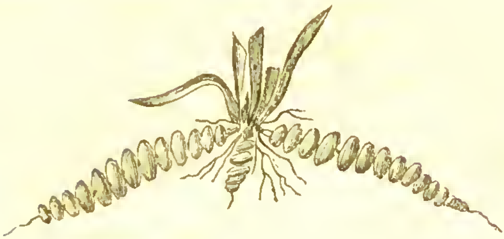
and flowers are seated. The structure of the tuber appears to be composed of a central part or pith, within a soft bark-like integument, covered with a thin cuticle, Fig. 24. Tubers are simple or compound; in the first, one principal gem or eye occupies the crown, as in *Cyclamen;* the second, besides a principal, is studded with many smaller gems dispersed over the whole surface, so that the smallest portion separated from the main body will become a perfect plant, as *Leontodon Taràxacum.*

Fig. 24.

Longitudinal section of a potato.

Tubers are of many different forms: rotund, as *Cròcus;* cylindrical, as *Cochleària;* spindle-shaped, as *Dàucus;* palmate, as *Pæònia*; irregular, as *Anèmone;* beaded, as *Arrhenathèrum,* Fig.25.; jointed, as *Nelùmbium;* bundled, as *Georgina,* &c. In duration, tubers are annual, as *Orchis;* biennial, as *Daùcus;* or perennial, as *Cyclamen.* They reproduce themselves above, as *Gladiòlus byzantinus;* laterally, as *Orchis;* and below, as some species of *Arum.*

Fig. 25.



In cultivation, we often see tubers, as well as bulbs, deviate from their natural manner of reproduction. The *Cròcus* for instance, instead of producing its new tuber on the crown of the old one, will sometimes, the Italian species particularly, send down a long shapeless rhizoma, having a new tuber on its apex, totally different from the common structure. Like bulbs too, if prevented from developing their stems in the air, they will throw out underground stems or runners, and produce new tubers plentifully without any assistance from either stem or leaves, as *Solànum tuberòsum**.

* This property of the potato deserves further notice; when an early crop is taken up from a hot-bed, some few of the tubers are left behind. These, instead of putting up stems in the air, exsert them in the ground, producing new tubers at short distances from each other on the runners, and which they continue to do for months together. In the fields we sometimes see, that after a dry summer, when the growth of both tops and tubers has been checked, and wet weather sets in before the crop is taken up, a numerous second crop will be produced—not from the original stems, but from the first formed tubers.

As we find the greater number of bulbous and tuberous stemmed plants, to be vernal flowerers, and that they chiefly rest during the heat of summer; it may be reasonable to conclude that these protuberant appendages are a necessary provision of nature to defend the vital organs against the effects of insolation.

A very conspicuous family in this group is the *Irideæ*. For splendour of colour—curious forms—and variety of specific characters, it vies even with *amaryllideæ*. The most striking physical character of the Iris genus is their tuberous stems, partly beneath and partly above the surface of the ground. Vital gems are seated not only at the summit but also on the sides of the stem; consequently it becomes branched. The stems also exsert roots from every part of their surface.

The order *Musàceæ* next claims attention, not because it is different in its elements and organisation from many of the preceding, but because it contains some of the largest herbaceous plants known. So magnificent, indeed, are the stem, leaves, flowers, and fruit of the *Plantain*, that it is commonly called a tree; it is however only a gigantic herb. The roots are fibrous, diverging from the compound collet, which throws up a succession of young stems as the oldest yield their fruit and die. The full grown stem is from five to nine inches in diameter, and from ten to fifteen feet high. The stem is chiefly composed of the bases of the petioles: and when the fruit is ripe it

is so completely herbaceous, that it is cut into small pieces, and used as green food for cattle. The Musa is one of the most useful tropical plants, as well for shade, shelter, and forage, as for its fruit, both green and ripe, as food for man.

The next orders as we ascend are *Cànneæ* and *Scitamìneæ*, which present no particular physiological circumstance worth notice, except that the irregular tubers of several of them are valuable as medicine, condiments, and nutritious food.

The *Orchìdeæ* are a remarkable tribe of plants. They inhabit both the torrid and temperate zones. Between the tropics they are mostly epiphytes, growing on the stems and branches of trees, or among the rotten leaves in their shade. Many of them ornament the meadows, moist dells, and woods of Europe; and where they are attractive of the most incurious eye. Their structure is equally interesting to the botanist as to the physiologist; and though their members are, in most cases, extremely singular in form and texture, their elements are cellular, with a vascular fabric and apparatus. Many of them absorb the whole of their sustenance from the air, especially if it be sufficiently moist: and though they attach themselves to the bark of trees, they are not, strictly speaking, parasites. Some of the American species have curiously jointed stems; and the British *Orchìdeæ* exhibit good examples of annual tubers; (Fig. 26;) that is, the new tuber formed last year, comes into flower in this, and when it has ripened seeds, and pro-

jected a successor tuber, becomes extinct. Thus these plants are perennial by a succession of tubers produced from each other, and not by duration, as is the case with *Anèmone*, or *Cyclamen*. A spontaneous motion is attributed to the petals of some species of this order, which is a phenomenon not yet satisfactorily explained.

Fig. 26.

a, the old tuber, which perishes with the leaves and flower; *b*, the new tuber.

Five other orders stand at the head of the class *Monocotyledoneæ*. Among the genera those of *Zàmia* and *Cycas*, are, from the form and texture of their appendages, the most remarkable. They have the appearance of dwarf palms; their foliage is of a rigid membranaceous character, and very durable. Their short, thick stems, are composed of the bases of fallen leaves in the same man-

ner as those of palms, only they never rise above a foot or two high.

Among the *Hydrocharideæ* we find the *Vallisneria*, the female flower stalk of which is physically curious. Being spirally elastic, it is contracted or dilated according to the depth of the water. The whole plant is submerged; the male flowers are deciduous and float on the surface; at which time the female flower rises to the surface, where a contact takes place.

SECTION III.—DICOTYLEDONEÆ.

We now enter on the most complicated forms of vegetation, namely shrubs and trees; and though many, perhaps the greater number, of plants arranged in this class are neither shrubs nor trees, yet as their organisation, and structure of flowers are similar, they are properly placed together: the circumstances of durability and ligneous character not being sufficient generic or specific distinctions in the natural system.

The chief physical marks of the plants of this class are, that they all rise with two or more cotyledons or seed leaves, and that they are invariably vascular. As it is only the physical, and not the botanical distinctions which are intended to be noticed in this review, the most *conspicuous differences* only need be pointed out; of the former there are com-

paratively few; but of the latter they are almost innumerable.

There is no natural mark by which shrubs are distinguished from trees. A large shrub may be called a small tree without impropriety; and *vice versâ*. The more humble stature, a weaker and more ramified growth, and a tendency to throw up a multiplicity of stems, are the most striking characteristics of a shrub.

The peculiarities which distinguish the kinds of trees, shrubs, and herbs from each other, consist in their manner of reproduction, constitutional character, special habit, and in their duration.

Reproduction.—Every plant is constituted to perpetuate itself by seed or by offsets in its native climate; and if diœceous the male and female plants be near together. Some plants reproduce themselves by seed only; others by seeds and also by viviparous progeny from their roots or stems. Some extend themselves by emitting roots from the branches, which entering the soil produce new stems; or by reclining on the ground strike new roots, whence proceed a new growth of stems and branches. Some others have stems resembling leaves, which being shed on the ground, become new plants.

Constitutional character.—Consists in the peculiar arrangement of the cellular element, the construction of the vascular and vital apparatus, in the durability of these components, the consistence and quality of the sap, the power of resisting the effects

of frost, and whether affecting dry ground or marshy places.

Special habit.—Whether leafless, or having leaves, whether these are deciduous in the first, or second, or persisting for several years. In manner of growth, whether prostrate, spreading, or erect; and whether the fruit be enclosed in a capsule, siliqua, legume, berry, pome, drupe, nut, or cone.

Duration.—Whether perfect in one, two, three, or in many years.

The above generalities will be more particularly adverted to in the sequel, and the plants named, in which these properties or distinctions are exemplified.

The lowest grade of the woody dicotyledoneæ are *Empètreæ*, being low inconspicuous shrubs, natives of northern latitudes.

The *Coniferæ* form one of the most imposing orders; their value in the scheme of creation for the purpose of shelter to animals, and ornament to the most bleak and barren regions of the earth; their combustible properties in cold climates; the great quantity and preservative qualities of their resinous juice, yielding extracts highly useful in medicine and in the arts; the easy convertibility of their timber to the purposes of the builder and mechanic, render this order one of the most important of vegetable productions.

Although, from the congruity of habit, hue, and predominating qualities of the *Coniferæ*, they form a very natural group, yet there are among them great constitutional differences. In some of the genera, as

*Tàxus** and *Taxòdium*†, every part of the exterior is furnished with an infinite number of buds either visible or latent, any one of which may be a principal, that is a leader, or a secondary, that is a branch. Other genera, or some individual species of genera, as the *Pinus sylvèstris*‡, are in general furnished with a definite number of buds; *one*, seldom more, of which is a principal, and all the rest secondary. In the first case, if the leader be cut off above the collet, latent buds immediately come forth, any of which may become a new leader, and throw out branches and branchlets innumerable; but if the leading shoot of the other be broken, the tree can never regain its natural form, because the latent buds are those of branches. Sometimes, indeed, the leading shoot of a branch, in consequence of the failure of the principal leader of the stem, will take a more upright direction; still the columnar form and aspiring character of the tree is seldom regained, unless a new leader springs from the collet.

It is obvious, therefore, that several of the *Coniferæ* have a determinate constitutional character, imposing a definite mode of development, and regularity of expansion; each bud, whether primary, secondary, or tertiary, &c., having its own peculiar powers, and without the faculty of becoming the substitute of another.

That some of this lofty and conical growing order possess latent buds in the collet, has been proved by

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* Yew. † Deciduous cypress. ‡ Scottish fir.

art. The lately introduced *Cunninghàmia* was found to strike roots by being layered in the usual way; but these being the points of branches, such they ever remained after being separated from the parent tree, and no confinement or training to a stake could alter their horizontal tendency. To procure proper leaders, therefore, the latent buds developed from the collet, were only found to contain the natural structure of principal stems.

It is not only in this instance we perceive the definite character in the structure of the regular growing *Conìferæ*. Sometimes it unfortunately happens that young firs and pines have their leading shoots killed by a late frost in the month of May; in which case, no art of the nurseryman can avail to recover the plants. They may continue to live, but never regain their natural forms, unless they are cut over. to induce the production of a shoot from the collet, which very few will do.

Notwithstanding this habitual regularity of growth, we sometimes witness deviations from that symmetry which distinguishes so many of the *Conìferæ*. Amongst the *Abiètinæ* or spruce firs, two or more leaders are sometimes produced, which will grow up together and share equally the central vigour and perpendicular extension of the axis. The *Pìnus stròbus* is often seen with a divided stem, especially when advanced in years. Indeed the whole order, after rising to their natural height, become bushy headed; the vigour of the axis appears then to be

transferred to the branches, a circumstance so conspicuously exemplified in the *Cèdrus Libàni.* The multifidous growth of the aged tree is constitutional; the irregularities observable in young subjects are accidental, caused by highly favouring circumstances of soil, situation, or seasons, and sometimes by wounds received from birds, squirrels, or insects.

The next order to be noticed is the *Amentàceæ.* It is divided into five sub-orders, which contain a majority of our hardy forest trees. The grand distinction is the separate station and form of the male flowers commonly called catkins, or botanically *Amèntum:* hence the title of the order.

The greater number of plants arranged here are very differently constituted to the pines and firs which have just been under review. We have observed that, among those, buds, or vital gems, are partially and pretty regularly disposed over the exterior of the plant; but on these the whole axis or body of the wood is enveloped in a cloak of vitality, impregnated, as it were, with latent buds in every part, viz. roots, stem, and branches. This is obviously certain as respects the *Sàlix*, *Pòpulus*, *Còrylus* and others; because every part or portion of these members can eject both roots and shoots in any situation and in any number, if surrounding circumstances be favourable. Hence the facility with which they are propagated, and the safety with which they may be cut over, pollarded, and trained for any purpose of fencing or the like.

The early development of the catkins in the spring has been already adverted to; and it may be added, that their sudden and conspicuous appearance on the poplar and willow, have the effect of even changing the face of the country where such trees abound.

The *Quèrcus* is the most important genus in the group, and this, together with *Fàgus* and *Càstanea*, yield valuable nuts, useful as food for both man and beast. The *Plàtanus Orientàlis* is no less curious in its mode of seeding, than remarkable for discharging its bark at a certain stage of its growth or age.

The interior structure of the *Amentàceæ* is in all of them very similar, differing only in the ponderosity, tenacity, and durability of their timber. That of the *Sàlix* and *Pòpulus* is soft and quickly perishable when exposed to the weather; the *Fàgus* and *Carpinus* have wood of a mild texture and dense grain, and that of the *Quèrcus* and *Castànea* is rigid, heavy, and durable.

The longevity of the trees in this order is more or less extended. Willows generally begin to decay sooner than any other. Alder is also comparatively of short duration. The Spanish chestnut and oak endure for many years. But there is a period of perfection incident to every tree, which has not been sufficiently studied by phytologists, and which well deserves attention.

All vegetable matter, when left to nature, is destined to decay after being deserted by the vital power

which swelled it into form. Thus we find that the first formations of trees, viz. the pith and its surrounding layer of wood, is the first to become decomposed. Now, could the time which elapses between the first year of the seedling, and the commencement of internal decay be ascertained, it would be an excellent guide for the operations of the woodman, merely for this reason, that he need never fell a tree, until it was in its prime, nor delay this business till it was too late. A timber tree is at its prime in the year before it begins to decay; if felled in or before that time, it falls sound; if after, it falls defective. This part of the history of trees will be resumed in another section; but it may just be added here, that the longevity is usually attributed to the suitableness of the soil and situation in which they chance to be placed; but of this plausible opinion we have no certain knowledge: for though rapidity of growth and measurable bulk are certainly entirely owing to these favourable circumstances; still there is doubt whether even the oak does not begin to decay at the heart, as soon in a rich, as in a poor soil. In a rich soil an oak may attain a great bulk in a comparatively short time, and be fit for the axe long before one planted at the same time on a hill of inferior soil; yet, of the two trees, that raised on the most *suitable* soil would be the most durable.

Nearly allied to the *Amentàceæ* are the *Juglàndeæ*, of which the common walnut is the representative. The North American hiccories, *Carya*, are elegant

trees, though they arrive at no great size with us: but the walnut is of great importance, as well for timber as a profitable fruit-tree. The wood is universally preferred for gun-stocks, and in time of war commands high prices. It may be said, that the power and projects of Bonaparte were not more fatal to the soldiers of England than to her finest walnut trees. Thousands upon thousands of these lofty ornaments of the old baronial halls of England, were sacrificed to repel the threats of the despot, or to the golden temptations of the timber dealers.

The *Piperàceæ* are mostly inconsiderable shrubs, or diminutive, trailing, twining herbs. The well-known qualities of their berries as a spice is, however, an excellence which obtains for them a distinguished place in the *hortus dietetica.* The leaves of the *Piper Bètel* are universally used as a luxury —indeed as a necessary of life, in India; hence the plant is extensively cultivated*, and with considerable advantage to the owners.

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* As the manner of cultivating the betel leaves is one of the most perfect processes of agriculture practised in Coromandel, a short account of it may be interesting:—A shady spot, liable to be inundated in the rainy season, or capable of having water introduced upon it from a tank or river, is chosen and fenced in. The surface is divided into parallel beds about six feet wide, with deep trenches between. Along the middle of each bed a row of *Æschynòmene grandiflòra* are planted about four feet apart. These beautiful trees are of a slender and quick growth; at the bottom of each, two or three plants of the pepper are put in; these grow lux-

The order *Ulmàceæ* contains only three genera, but the type is one of our most ornamental and and useful timber trees. The English elm is not a forester; no old trees being met with except in the vicinity of buildings, or marking the place where such have formerly stood. It is said that this tree was introduced into England from Palestine during the crusades; and from the many fine avenues, and hedge-rows still remaining about noblemen and gentlemen's seats, it appears there existed at one period "*a rage*" for planting elms. Considered constitutionally, this tree is a mass of vitality; every part of its exterior, root, stem, and branches, is studded with either latent, or visible buds. No tree bears pruning so well as the elm; and where it is once planted, there it, or its viviparous progeny, ever remains: a fortunate property of a tree which

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uriantly, and run up the stems of the trees, yielding abundance of leaves, which are gathered from day to day, made up into little parcels of a score or two, bound with a leaf of *càrex*, and so sent to market. Such a plantation is productive for years when well taken care of, and is considered a profitable possession. The leaves are called betel, because they are used with the *betel nut*, which is the fruit of the *Arèca catechu* palm, so highly esteemed for its exhilarating effects on the nerves when kept in the mouth as a quid. When used, a piece of the betel nut about the size of a Mazagan bean is wrapped in part of a pepper leaf, along with a little chunam (red limestone pounded); together forming a pellet, which is placed within the cheek. The lime corrects the acridity of the pepper, and the whole excites a flow of saliva—agreeable enough, perhaps, in a torrid climate.

rarely ripens seed. Where a succession of young stems rising from the roots of the old trees is considered desirable, *grafted* plants should not be chosen; but those raised from *layers* only. Elm timber is tough and durable, but very liable to warp, owing to its sap being so slowly fugitive; as it continues to shrink for twenty years after being used as weather-boarding.

In considering the physiology and the vegetative powers of the elm, we are struck with how little one part of the system depends on the others. The whole axis of wood may be scooped, or rotted out even to the last year's alburnum, and still the outside shell, consisting of little besides the vital envelope and bark, will continue to put forth new shoots; and even if severed from the root and decapitated, the butt, lying in a shady place, will still exsert shoots and leaves for several years.

The next order is the *Urticeæ*, and of this we may venture to assert, that were the different genera it contains assembled together so as to be seen at a glance, no one but a rigid systematic botanist would pronounce it a natural association. Here we find the cultivated fig, and the common nettle; the bread-fruit tree and the hop; no two of which bear the least resemblance to each other. But, as all the genera agree in their mode of florescence, they are, on this account only, brought together. Notwithstanding the dissimilarity among the plants forming this order, several of them have a property in common which

proves their affinity. Besides the hemp (*Cànnabis*) others are furnished with filaceous matter in their stem which, when properly prepared, is useful to the spinning and weaving manufacturer. Of the *Cànnabis* it may be observed, that the male flowers are sometimes surmounted by a few female florets, which is an aberration of nature. Some other plants present the same phenomenon, as the *Zèa*; but such circumstances, though constitutional, are merely incidental and attributable to the effects of high cultivation.

The common nettle has an uncommon power of dispersing the pollen. Under the excitement of bright sunshine the anther discharges the pollen from an aperture in clouds resembling the smoke from a musket. This appears to be effected by an elastic gas suddenly set at liberty with the pollen, or to the collapsion of the pellicle of the anther after the opening is made. This phenomenon, though not an inviting scene for a refined naturalist, is really amusing. By standing in the shade of high nettles in a hot day, the quick succession of explosions among the flowers, is not unlike bush-fighting between the light troops of hostile armies!

The next order which offers any thing interesting to the physiologist is the *Euphorbiàceæ*. The milk-like juice so prevalent in the tribe, is a good mark of distinction; and being so different in colour and consistence from any thing that can be absorbed by the plants, is proof that it is the plant itself which concocts and prepares its essential qualities. Castor oil

is obtained from the seeds of *Rìcinus;* Caoutchouc from *Siphònia;* and many drugs are obtained from the different genera. *Phyllànthus* and *Xylophỳlla* are found in this order; of these the physiologist will not fail to notice that the leaves act as peduncles to the flowers and fruit.

Cytineæ contains only one genus, but that a very remarkable one, viz. the *Nepènthes* or pitcher-plant. The ends of the leaves are resolved into hollow vessels containing water, and having a moveable lid, intended, it would appear, for some peculiar purpose of the plant, not yet clearly accounted for. The circumstance of marshes being the habitat of the *Nepènthes*, implies that any extra store of water would be superfluous; and therefore this provision is the more extraordinary.

The next order, *Asàrinæ*, contains *Aristolòchia*, a half-shrubby twining genus. The grotesque shape, uncommon colours, and disagreeable scent of the flowers, are certainly more attractive to the physiologist than to the florist; but as a contrast, and to enhance the value of elegant and sweet-scented plants, *Aristolòchia labiòsa* should have a place in every stove collection.

Passing the three orders *Elæàgineæ*, *Santalaceæ*, and *Osyrìdeæ*, which present not any thing physically interesting, we come to *Thymèleæ*, which may be noticed because of the tenacious character of the ligneous fibres abounding in the stems of *Dìrca* and others; and for the distinctness and want of cohesion

among the layers of the interior bark, which separate from each other, like those of the lime, with the greatest facility.

The *Proteàceæ* are an estimable order of plants, distinguished by their ample flowers being supported by a profusion of bracti, and, in many instances, as highly coloured as the corolla. The *Proteas* are natives of South Africa. But the *Banksias*, *Telopea*, &c. were among the valuable acquisitions made by the enthusiastic exertions of the celebrated naturalists, Sir Joseph Banks and Dr. Solander, while exploring the southern coast of Australasia, under the guidance of the intrepid and lamented circumnavigator, Captain Cook. The discoveries then made, not only gave a name to an extensive country, on which British colonies have been founded, but gave also a vast addition to our *species plantarum:* of tribes of plants, too, differing from every thing before known to the botanical world. Nor is this fertile source of vegetable beauties yet exhausted; every year bringing us fresh supplies of nondescripts to enrich still more European collections.

The order *Myristìceæ* contains two genera, one of which is the highly valued nutmeg with its investment of mace. The *Myrìstica officinalis* is a handsome middle-sized tree; the stem is erect, throwing out branches at regular distances, disposed verticillate in fours, spreading obliquely upwards; smooth grey bark; leaves alternate on footstalks; ovate, acute, shining dark green above, paler below.

This tree is common on most of the islands in the Indian Archipelago, and on the continent of Malacca and Siam. There are varieties of the nutmeg; as the true sort, received from Ceylon and the Molucca islands, are smaller, rounder, and higher flavoured than those produced in the woods of Malacca. The vitality of the nut is destroyed in the process of preparing it, with salt water and lime, for exportation.

The *Laurìnæ* are a distinguished order of trees and shrubs, as emblems, ornamental trees in gardens, and in commerce, as producing the finest spices or aromatic oils. Two new orders have been taken from the genus *Laùrus* as arranged by Linnæus; viz. *Cinnamòmum* and *Pèrsea;* the first yields spices chiefly, and the last an edible West India fruit, namely the alligator pear. The *Cinnamòmum camphòra* is one of the principal forest trees in the southern provinces of China; the *C. verum* and *C. cassia* are also found there; but the best cinnamon (the inner bark and vital envelope of shoots about half an inch diameter) is produced in Ceylon and other islands in the same latitude.

Polygòneæ contain many worthless weeds, but among them we find the excellent medicinal rhubarb, now doubly valuable as an article of diet. The seeds of *Polỳgonum fagopỳrum,* yield the distiller an ardent but pernicious spirit, if not qualified by some milder principle. As food for cattle it should always be used with caution.

Begoniàceæ are a beautiful family of tropical herbs, remarkable for the rich colour and unequal shape of the leaves of many of the species. Some of these have tuberous under-ground stems; showing that they are impatient of, or liable to suffer by, drought.

Chenopòdeæ are mostly inconspicuous and worthless weeds. Some of them, however, are valuable as spinaceous herbs, and the monstrous spindle-shaped stems of the beets are important to the cattle-feeder, the sugar-manufacturer, and even, it has been lately discovered, to the brewer. *Chenopòdium* and its alliances are covered with minute globules of membranous matter and moveable under the touch, giving the idea of oiliness.

Phytolàceæ and *Amaranthàceæ* are kindred orders; the first yield strong medicinal principles, the second are valued for their showy flowers, as *Celòsia, Gomphrena*, and *Amarànthus*. The *Amarànthus oleràceus* is cultivated and used as spinach in India.

Nyctagìneæ and *Plantagìneæ* are remarkable for being mostly destitute of corollas. The Marvel of Peru is the most ornamental of these orders. These conclude the sub-class *Monochlamýdeæ*.

Plumbagìneæ and *Globulària* are placed at the bottom of the sub-class *Corollifloreæ*, but offer nothing peculiar.

Primulàceæ include some of the most admired floral beauties; viz. *Cýclamen, Soldanèlla*, and the genus that gives the title to the order. These are

the chief ornaments of the mountains and meadows of Europe. The round tubers of the *Cỳclamen*, the long irregular one of the *Auricula*, both of which are perennial; and the annually increasing crown of the *Dodecàtheon* are all worthy of the attention of the physiologist.

The order *Orobàncheæ* contains but two genera, both very curious; namely, *Lathræa* and *Orobànche*. Instead of leaves they are furnished with bracteous scales, foliage, it seems, not being necessary to them, as they subsist on the roots of other plants. Broom-rape (robber of broom?) affects the roots of common broom, and also those of the biennial red clover, sometimes in such quantity as to form a considerable part of the bulk of the second crop. It is seldom seen on arable land except with clover. As it is cut, carried, and thrashed with the clover seed, may it not be sown with it? The *Lathræa* has an extensive system of filamentous roots, and seems to seize on dead vegetable matter, as well as on the living roots of other plants.

The succeeding orders of *Acanthàceæ*, *Myoporìnæ*, *Verbenàceæ*, *Labiàtæ*, and *Scrophulàrinæ*, contain plants of various characters as to form, colour, and essential qualities, many of which are cultivated as pot herbs; but exhibit no peculiarity in their structure worthy of notice.

Solàneæ are an eminent subdivision of the vegetable kingdom. In it both poisonous and sanative principles are found. The deadly nightshade, intoxi-

cating tobacco, the pungent capsicum, and the useful potato are all associated here. In no other order are opposite and extreme qualities so closely allied, nor is diversity of constitutional structure more apparent. The *Solànum tuberòsum* may be noticed, not because of its great value as an article of food, but for its uncommon powers of reproduction. Besides seed, it produces tuberous progeny on the stem as well as in the ground. Some dwarf varieties which yield numerous and early tubers, are often barren of flowers and seed; but which they may be made to produce, if they be robbed of their tubers, as soon as they are formed. And if the flowers be picked off the free flowering sorts, their tubers will be increased in size and numbers. Both these facts were discovered by T. A. Knight, Esq., P. H. S., and are striking proofs of the connexion there is between the oviparous and viviparous principles of the plant, or rather the power each has of neutralising the other, as has been before alluded to in the case of bulbs.

Passing over several orders we stop to notice *Convolvulàceæ;* among which we find the very useful tropical plant *Ipòmæa batàtas*, which yields, when properly cultivated, tubers of a far larger size, and nearly equal in value to those of the potato. The leafless *Cùscuta* is also ranked here, a most remarkable vegetable parasite; its proper roots are only useful during the infancy of the plant; for as soon as its hair-like branches lay hold of any living support, its

own roots perish. The twining stems of *Convolvulàceæ* are a most unaccountable phenomenon; and are a fit subject for the investigation of the physiologist.

The next peculiarity of structure requiring notice, occurs in the *Bignoniàceæ*, which is the manner in which some of them attach themselves to the bark of trees, rocks, or buildings for support. This is accomplished by fibrous processes issuing from the bark of the young shoots; these produce other fibres laterally, which, having flattened ends, seize on the asperities and chinks of the supporting surface, thereby gaining a firm and secure hold.

The *Asclepiàdeæ* and *Apocỳneæ* are only remarkable for the curious structure of their flowers and deleterious qualities of their juices. The genus *Stapèlia* are succulent plants, consisting of thick fleshy stems, either erect or lying on the ground. Many of them have irregularly quadrangular shoots, bearing flowers of the most grotesque shape and colours, but wholly destitute of leaves.

Jasmìneæ and *Olìnæ* may be called household orders, being so well known. That the *Fraxinus* should be ranked with the olive is rather curious; but their natural relation is proved by the readiness with which they take, when worked on each other.

The *Ebenàceæ* are worthy of note, because the *Diospỳros ebenum* furnishes one of the most precious and hardest kinds of wood. No other of the *Corolliflòræ* require remark.

At the bottom of sub-class *Calyciflòræ* are

Peneàceæ and *Ericeæ* embracing the greater number of the ornaments of our green-houses and shrubberies. For delicacy as well as amplitude of foliage, splendid colours, and varied form of flowers, the *Ericeæ* stand unrivalled.

A majority of the orders of this sub-class are distinguished from each other by botanical synonymes rather than by physical differences. To enumerate them is therefore unnecessary: the orders *Compòsitæ**, *Rubiàceæ*, and *Umbelliferæ*, however, are particularly well marked in exterior form; but it is not till we arrive at *Opuntiàceæ* that we meet with any thing constitutionally different. In this last-named order we find no resemblance of either herb, shrub, or tree, in the common acceptation of these terms. Here we see vegetable bodies of regular, as well as of most grotesque forms; some of them destitute of branches, and almost all of them of leaves. In *Epiphyllum* and *Opùntia*, the stems are flattened to do the office of leaves, and also of peduncles. The *Mammillària*

* Among the *Compositæ* we find the *Elephantòpus*, a singular production. This plant has fibrous roots and proper laxive stems annually put forth. Its principal accretion is concentrated in the collet, which becomes monstrous and assumes a ligneous character, becoming hollow within. The bark of the tumour is increased in thickness like that of trees; and is very regularly fractured by the annual growth.

These annual growths are pretty distinctly marked in the bark: and by which the age of the plant may be calculated with great certainty. Sòme individual plants have been seen at the Cape of Good Hope above two hundred years old.

are mostly hemispherical bodies studded with mammæ, and thickly beset, as are most of the other genera, with rigid spines.

Fícoideæ and *Crassulàceæ* are kindred orders, though perfectly distinct in a botanical point of view. The leaf-like appendages of the latter, and some of the former order, as well as *Opuntiàceæ*, cannot be considered simple leaves, because they contain all the principles of the entire plant. Any one of those members separated from the parent and placed in favourable circumstances, readily ejects roots and becomes a perfect plant. *Bryophýllum* produces viviparous progeny from the crenature of the leaves. In short, many of these succulent plants, composed of thick masses of vegetable matter interspersed with membranous fibres and sap vessels, can only be considered as consisting wholly of stem; and this plenished in every part with the reproductive organs of vegetable life.

Passiflòreæ and *Curcubitàceæ* are conspicuous orders; the first for the grandeur of their flowers, the second for the usefulness of their fruit; both furnishing fine objects of study to the physiologist, whether he regards the causes of the variety of form and colours of the one, or the manner of the enlargement of the enormous fruit of some species of the other. Melons, cucumbers, gourds, &c., are well known exotic fruit-bearing herbs, formed for climbing, though generally trained on the surface of the ground. They are pruned and managed in the manner of fruit

trees, a good deal of attention being required to check the natural luxuriance of their growth, and dispose them to yield their fruit in the shortest possible time. The fruit are produced on the side branches of the leading shoots ; these, therefore, are stopped in the early stages of their growth, to ensure the production of a tertiary order of branches, which are usually fertile.

Next is the order *Myrtàceæ,* containing many beautiful as well as useful plants. Among them a singular instance of inflorescence is exhibited by the *Malaleùca,* which ejects its flowers in long whorls from the bark of the young wood. In looking over the remainder of this sub-class we meet with many objects of floral beauty, and numerous genera possessing highly valuable medicinal and other useful qualities ; and in which, moroever, though variety of form, texture, and disposition of vegetable elements are really admirable, still there is no one genus so decidedly different from others as to require particular notice. We may, however, notice the order *Rosacèæ,* and *Legùminosæ;* the first contains many fine fruit trees, and among them should not be forgotten the estimable though humble strawberry. The constitutional structure of this favourite plant may be described as consisting of a compound crown, having one bud central and principal, surrounded by inferior gems of two descriptions, namely, branches and runners. The principal bud is developed and produces flowers and fruit in the second year ;

during which runners are detached, and the branches are advanced by displaying a new set of leaves, preparatory to yielding flowers and fruit in the third year; in which season they also send forth runners, and numerous side branches, intended to extend the stool in all directions around. But it appears that, as the flowers are terminal, a bud cannot yield two crops; and as every new set of succession branches becomes more and more diminished in strength, cultivators find that the original plants are not profitably kept after yielding two crops, unless they are well dressed, and enjoy a favourable soil. So that it is only the produce of the principal bud, and that of the first set of branches in the third year of the plant's existence, that are considered as compensating for the trouble of cultivation. The runners sent off from the main body of the stool eject roots of their own, and soon become independent of the parent plant. The *Leguminòsæ* are a most conspicuous order. Their papilionaceous flowers and curiously shaped pods distinguish the greater number of them from all other plants. This order contains some of our most elegant trees and shrubs, and our wastes are enlivened by the golden-flowered broom, and ever-flowering furze. The most inconsiderable herbs, and the most stately trees, are also found in this order.

In the sub-class *Thalimifloræ* we see only, as in the preceding, variety of forms and qualities without any striking physical differences. We may, however, notice *Impàtiens*, merely for the purpose of alluding

to the dissilient property of its capsules, which, when ripe, burst with such force as to scatter the seeds to a considerable distance around. *Tìlia*, or lime tree, is noted for its distinct and easily separable layers of bark, of which Russia mats are made. It has been said of this tree, that its liber is double, or that it produces two layers in each year; but this requires confirmation. The filaceous coverings of the seeds found in the capsules of the *Gossìpium*, are no less curious than useful; and the fine tenacious fibres of the bark of *Lìnum* should not be overlooked. The form of the leaves of *Saracènia* is remarkable; and the creeping rhyzomas of the *Nelùmbium* deserve the attention of the cultivator.

ORGANIC STRUCTURE OF DICOTYLEDONOUS PLANTS.

Having in the foregoing essays described the elements and the manner of the growth of vegetables; noticed their arrangement by Jussieu; and taken a brief view of a few of the orders, from the most simple to the more complicated and perfect plants; we have now to notice the constituents and organisation of the superior orders of *Dicotyledoneæ*, with a view to the illustration of those expedients of propagation and culture which are practicable only because they depend for success on the physical properties and powers of the plants themselves.

The members of a dicotyledonous plant are the seed, root, collet, pith, perfect wood, imperfect wood, vital membrane, liber, bark, leaves, armature, flower, and those coverings of the seed called the fruit, with its appendages.

In describing these different components it will not be possible to avoid reiteration; many circumstances before alluded to, or described, must be again mentioned; but as the writer wishes above all things to make himself clearly understood, periphrasis, he hopes, may be excusable.

Seeds.—Are the oviparous progeny of plants. When naturally produced, that is when art has not interfered to change their constitutional properties, they contain the rudiments of a vegetable, capable of

being developed into the perfect form, and endowed with all the powers and qualities of that which produced them. That the future plant exists in embryo in the seed can scarcely be doubted; and though it is not easily conceivable that "the monarch of the wood" once reposed in an acorn! yet it must be admitted as a highly probable fact; because, as has been before observed, vegetable growth is not an enlargement by addition of new, but only an amplification of pre-existing parts. The inherent qualities are certainly augmented by the assimilation of the nutriment absorbed by the plant, by which also the cellular structure is enlarged and distended; but this cannot add one additional cell to the structure.

We are well aware of how some chemists account for the accretion of plants by saying, that as vegetables are wholly composed of oxygen, hydrogen, and carbon, they are endowed with the power of extracting from the earth, air, and water, constant supplies of these chemical bodies to form all the newly developed parts which annually enlarge their volume. No one can rationally doubt the above position; but the same philosophers go much farther, and maintain, that not only are vegetable elements so accumulated, but that the organisation itself is generated by combinations of them in a manner not easily conceivable by those not versed in chemical science. The fact is, vegetable growth, as observed above, is only an amplification of pre-existing organisation.

That this idea is not merely hypothetical may be

averred, first, from the circumstance, that in the large bulb-like seeds of some of the *Monocotyledoneæ*, a considerable portion of the infant plant is distinctly visible on dissection, and the reason we see so little in these, and especially in small seed, is only owing to our limited powers of sight, and limited means of assisting those powers. Secondly, the seeds of *Diœcious* plants are male and female, and to the experienced eye are detectible before germination, especially in the genus *Cannabis;* which is a proof that neither the sexes nor other specific form of the plant depend on any fortuitous combination of vegetable elements when not deranged by cultivation. Besides, the general resemblance of the parents and progeny from generation to generation among plants in a state of nature, is indubitable proof that the seeds inherit the rudiments of a perfect form, however diminutive, from the first.

The structure and components of seeds have already been noticed as consisting of various coverings, inclosing the cotyledons and infant plant. When germination takes place these coverings, intended for the preservation of the vitality during the inert state of the seed, are burst asunder, to allow the protrusion of the root, the cotyledons, and stem.

The Root.—Is first a blunt spur-like body, tapering as it descends into the earth, and exserting from its sides slender fibres, which are the receptive organs that collect the pabulum of the plant. These fibres are said to have a contractile power, by which they are withdrawn from dry air, and extended again into

that which is moist. As the roots progress in length they become divided and sub-divided into numerous ramifications. Such roots are properly called fibrous, not only because they are so at first, but because their extremities are always so; and though those of trees become in time immensely incrassated towards the collet whence they originated—they are still considered and called fibrous.

All plants are furnished with fibrous roots, but under different modifications of size and duration. Those of herbs are fugitive, in many cases annually dying off in the autumn, and renewed in the following spring; of shrubs and trees the principals are permanent, with annual growths of young fibres. These principals appear to be only subterranean portions of the axis or stem; because in most cases their components and structure are similar, except that they have no pith; in this respect only they differ, both having concentric layers of perfect and imperfect wood, a vital envelope, liber, and numerous folds of bark; and in many instances both are furnished with incipient buds, which, when developed on the stem, are called shoots, but if from the root, are called suckers.

The natural direction of all roots is from dry air and light, to moisture and darkness. The ascent of the *plumùla* or infant stem may be in general satisfactorily accounted for; but the contrary notion of the *ròstrum*, or first root, is not so easily comprehended. The latter is either repulsed by dry air and light, or attracted by moisture. Whether in the

earth or in pure water, roots invariably descend till they are out of the influence of dry air. This, from its withering effect, prevents all ejection of the delicate and sensitive spongioles; and to escape from it, in ordinary circumstances, their course must be downward. To prove that there is no constitutional tendency in roots to obey the law of gravitation (as has been supposed) they will take an entirely opposite direction in quest of moisture, as may be seen within the overhanging banks of roads or rivers when the bank has been undermined.

Although fibrous roots are only ordinarily produced below the collet, yet the power of exserting them is not wholly confined to that part of the system; they are readily ejected from the stem, branches, and even the leaves also, under certain circumstances; but this will be adverted to when we describe that member of the plant whence roots usually proceed.

It is observed of radicles that they have the faculty of extending themselves towards humid heat, or to their food, whether that be simple water or nutritious gas. Is this a spontaneous and inherent power by which their organic action protrudes the fibres outward, or are these sensitive bodies attracted by the qualities to which they trend? This phenemenon can only be attributed to the universal law of attraction, as mentioned at page 22.

The incidents which show this sensitive inclination of roots, are the following.—If a tree be planted on the bank of a river, or on a spot of inferior soil near a bed of superior quality, a majority of the roots in

both cases will be prolonged towards the river and the richer soil. If a plant be so placed, that a greater degree of moist heat exist on one side than on the others, the roots will all trend towards the warmth. Again, if a solid body (which is retentive of heat, or, if cold, is attractive of moisture) be within reach of fibrous roots, they will extend towards and spread themselves on its surface, and seem to luxuriate in the cavity formed by the side of the solid and the soil.

Roots both ascend and descend from their accidental stations in the soil to reach more suitable aliment. Those of the ash will cross from one side of a deep ditch to the other; first descending when they reach the brink, passing under the bottom, and again ascending the opposite side till they arrive at the due point under the surface, whence they resume their horizontal course, keeping a uniform distance (about ten inches) from the air throughout their range. Mulching with rotten manure will bring roots to the surface; and in dry seasons they will descend even into deleterious subsoils in quest of moisture. This last circumstance should be guarded against by the orchardist if possible; for though it may be irrational to suppose that roots can be attracted by destructive qualities, yet the want of moisture may induce them beyond a proper depth.

Although all plants are furnished with fibres, which issue from the extremities of the descending *caudex*, or immediately from the collet, there are, besides, other processes ejected by the latter organ which cannot with propriety be called fibres; such are the

large fleshy roots of asparagus, (Fig. 23,) and the like. These are evidently preservative appendages containing a store of nutriment for the use of that part of the crown to which they are attached. In fact they are only a modification of a tuber, but with this difference—they are destitute of buds or of any principle of reproductive life, save that which they possess as an appendage of the crown.

The fibrous roots and stems of shrubs and trees are increased in thickness together. Whilst the stem is receiving a new layer of alburnum, the roots also receive an addition of the same kind. It is from this circumstance that roots are known to be more enlarged toward autumn than at any other time of the year.

Some practical men are of opinion that the principal office of the roots is only to fix the plant in the earth. They infer this from observing that some plants live entirely in air; that in the order *Pandāneæ* and its alliances, the first roots only are produced from the collet, and all the subsequent ones from the stem; the roots of cuttings moreover are produced by the stem, protuberances are formed above wounds and ligatures; and there are many instances of accretion or enlargement of the inferior parts of plants, which is evidently received from the influence or action of the organisation above.

Admitting that these instances are corroborative, to a certain extent, of the opinion above alluded to, yet, from the ordinary and well-known functions of the roots in supplying water and nutrition on all occasions to the head, it is impossible we can con-

sider these two divisions of the plant in any other light than as "correlative parts" necessary to the system; and therefore by no means entirely independent, notwithstanding we often see them acting in the absence of each other: felled trees produce shoots, and the roots of trees and deep rooting herbs will continue to throw up sap for a long time after the head and stem are cut off.

The Collet.—This is that part of the axis which divides the stem from the root of a seedling. It is the seat of the cotyledons—the crown of the roots—and the base of the stem. It is certainly a distinct member of the plant, especially in the early stages of life; and has been so considered by many eminent botanists. Fischer and Treviranus call it *centrum vegetationis;* Turpin termed it *ligne mèdiane;* Professor Hayne of Berlin calls it *nodus indifferentialis;* and Lamarck, and many others, the *life-knot.* (*a.* Fig. 8.)

If a seedling of an herbaceous plant, and of many kinds of trees, be cut over below the collet, the root invariably dies; but if above, except some kinds of *Coniferæ, Pàlmæ,* &c., the root will continue to live, and new shoots will be produced from the collet.

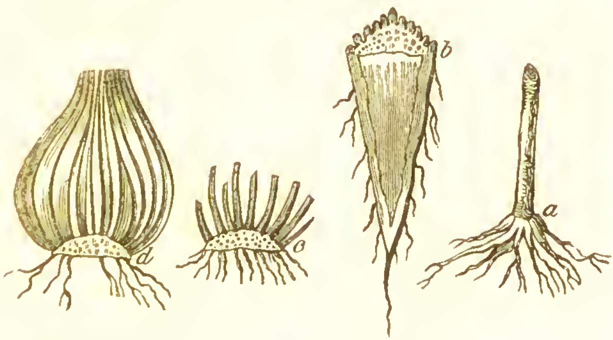
Trees whose root, stem, and branches are studded with incipient buds, as the myrtle for instance, contain a much greater number crowded together in the collet than in any other part. It is on this account that portions of the protuberant part of it are chosen and planted for the purpose of propagating the olive, in the south of Europe. The nodes of jointed stems

are constituted (in respect of being the seat of many buds) like the collet; in the vine, for instance, the latent buds in the nodes appear to be inexhaustible.

In the greater number of aged trees the collet cannot be discerned. This is particularly the case in such kinds as produce suckers. Others there are whose collet is protuberant with the remains of former shoots; or accidentally, as we often perceive the Spanish chestnut to be on dry ground.

The collet is in most cases the partition between the ascending and descending parts of the plant; in bulbs it is the radicle plate; of herbs and fusiform tubers it is the crown; and in trees and shrubs it is called the collar or collet. (Fig. 27.) It is moreover the base of the pith, which is the central organ of the member which next falls to be described.

Fig. 27.



a, example of the collet as it appears in trees and shrubs; *b*, on fusiform underground stems; *c*, on herbaceous plants; and *d*, on bulbs.

The Stem.—The stem or axis of plants is that columnar body which serves to support and elevate the foliage and fructification. It assumes many

different forms and characters, as to bulk, structure, position, place, and duration.

There is, perhaps, no such thing as a stemless plant in nature, notwithstanding the term *acàulis* is often used in botanical descriptions. There is always some member between the root and fructification, whether that be a tuber, bulb, scape, peduncle, or ligneous column. The term is, therefore, to be understood as only signifying that the plant is destitute of an elevated flower stem, as *Enothèra acàulis.*

The stem or trunk differs in size, from a diameter of many feet to that of a bristle. In structure they are solid or hollow—jointed or simple—single or numerous. In position they are erect—inclining, prostrate, pendent or involving. In place they rise in the air, creep on the surface, or enter deep into the ground. In duration, if succulent they quickly become decomposed ; if ligneous, they continue many years before they fall to decay. The following are examples of these different characters.

The *Quércus ròbur,* some of the *Coniferæ,* and the *Fāgus Castanèa* attain the greatest magnitude in temperate climes, and the *Bòmbax*, *Adansònia*, *Tectònia,* and perhaps the *Swietènia**, are the most stately genera in the tropical groves.

The oak is also an example of a solid trunk before its decay, and the best examples of hollow stems are

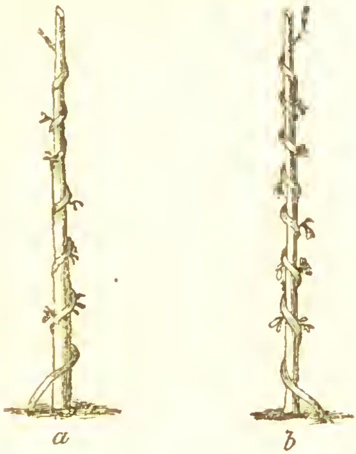
* The writer is uncertain whether the mahogany be, or be not a lofty growing tree ; but from the *soundness* and great size of the butts imported from Honduras and other places, it is quite evident that the tree lives to a great age before it decays at the heart.

the *Bambùsa arundinàcea*, among trees, and such as the *Lychnis coronària*, among herbs.

The *Vitis vinìfera* is a type of a solid and jointed stem, and the *Jùncus filiformis* of that of a simple one. Single trunks are exemplified in palms and some of the *Conìferæ*, and a plurality of them are shown by the *Philadèlphus coronārius*.

Erect stems are such as the *Araucāria imbricāta*, and others of the *Conìferæ* and *Palmæ*. Inclining, as the *Lārix pendùla*. Prostrate, as the *Fràxinus pendūla*, and *Fragāria vesca*. Pendulous*, as *Cēreus flagelliformis*. Involvate, or twining from west to east as *Phaseolus*, or from east to west as *Humūlus*.

Fig. 28.



Twining or spiral stems. *a*, French bean; *b*, the hop.

* Although there cannot be, in fact, any such thing as a pendulous stem on a level surface, yet the *Cereus* specified being an inhabitant of craggy precipices, the position of its pliant stems is generally pendulous.

Seed-bearing stems are always exhibited in the air, but the lower parts of them are, in many instances, prolonged downward in the soil, as *Dàucus carròta*, and *Còchleària armoràcea* *, or extended horizontally therein, as *Agropyrus rèpens* †, and as are those of aquatic plants in the mud, as *Nelùmbium speciòsum* ‡.

Fig. 29.

An aquatic plant extending its stems in the mud.

The bulbous stem has been already described. Tuberous stems, as the turnip, are casual enlargements of the pith, covered with the proper integument of the stem, but also greatly thickened and pulpy. This, as well as the incrassated stems of *Dàucus*, *Pastinàca, Bèta*, and others, are, for the most part, only the effects of cultivation. The tubers of *Heliànthus*, and *Solànum tuberòsum* §, are the abbreviated and engrossed points of subterranean stems of the plants. Of such subterranean stems there are modifications, and they may readily be distinguished from what are properly called tuberous roots; the former

* Horse radish. † Couch-grass.
‡ Water-lily. § Jerusalem artichoke and potato.

being furnished with latent buds or viviparous principals, whence new plants are produced, while the latter are not. The *Pæònia* furnishes an example of the tuberous root.

Fig. 30.

Ligneous or woody stems are composed of several distinct members which may be described in the order of their position, beginning with

The Pith.—This member occupies the centre of the stem, and constitutes the principal part of the bulk of the seedling, and of every young shoot. It is more or less filled with spongeous, cellular matter, divided into large longitudinal locoments, easily permeable by the fluids of the system. (Fig. 1.) Although its apparent use is to strengthen the young shoot, and to act as a duct or reservoir of moisture, its structure and numerous hollow spaces show, that it may be also a chamber for containing an elastic gas, which when acted on by the heat of the air, must necessarily assist to distend and elongate the sheath in which it is contained. There seems to be no action in the pith (except as a duct) after the first year, for as it increases in age it decreases in volume; and in old stems becomes almost obliterated. A thin sheath

of dense cellular matter encloses it, and to this the first concentric layer of wood is attached. In hollow stems pith is only found at the articulations; and in jointed stems which are solid, the pith is interrupted at each joint. It is also somewhat interrupted at the base of every branch of a simple stemmed tree.

The Wood.—This member is simultaneously produced with the pith which it surrounds. It appears in three different states during its growth. At first it resembles a semi-transparent mucus: next an inspissated jelly showing faint signs of organisation; and last as alburnum, possessing all the fibrous structure, tubes, sap vessels, and other components of perfect wood. It is the lateral expansion of this member, and that of the pith, which increases the diameter of the seedling stem. During its growth it is the seat of the vitality; but ceases to be so as soon as the summer growth is over. This is demonstrable by the fact, that the first formed concentric layer of wood ever remains of the same dimensions it acquired in the first year.

If this first layer of wood be examined in the autumn, we find its exterior side formed of denser cellular matter than the interior; the latter being more porous, owing to its containing larger and a greater number of tubular openings. We can also discover radiating partitions of close cellular substance perpendicularly placed, diverging from, or converging to, the pith, and dividing the ligneous layer into segments. These partitions are not so conspi-

cuous in the first concentric layer as they are in those which are afterwards imposed; and are the glossy waves of the grain of timber exposed by the plane, and so conspicuous in oak when cut into panels. This description of the growth of the cylinder of wood of the first year, applies to those of every shoot afterwards made by the tree, and also of every layer of wood which annually enlarges an old stem.

The Bark.—The next visible member of the seedling stem is the outer covering or epidermis, consisting of a thin colourless cuticle, inclosing a coat of parenchyma. It covers the *plumula* before its expulsion from the seed, and continues for ever after on the exterior of the stem; although, on the generality of shrubs and trees, it becomes so much distended by the internal growth, that its identity disappears. Another member of the bark starts into visible existence at the end of the first summer, namely, the liber. This is at first a part of that member described as the wood; but is discharged therefrom at the end of summer, and then being distinct receives the name of inner bark or liber.

The bark is an excrementitious part of the plant. It is increased in thickness every year, during the life of the tree, by new layers of liber added to its interior surface; so that the numbers of layers of bark, like those of the wood, always indicate the age of the tree. This, though a general rule, has some exceptions; as exemplified in the *Arbùtus andràchne* and the *Vìtis vinìfera*, which plants discharge their outer bark every second or third year.

In old trees it is only a few of the inner layers that participate in the vitality, or act organically in the system. All the outer layers serve only as a covering: and these, if not thrown off, or cracked into longitudinal fissures, or stretched horizontally to make room for the internal accretion, actually check the growth and hasten the decay of the tree.

Bark, in the generality of trees, is thicker or thinner according as the growth of the stem has been rapid or slow. Trees that stand singly, or on elevated situations, and consequently exposed to full air and every wind that blows, increase in diameter of stem and extent of branches much more in proportion than if they had been drawn up in close plantations or in sheltered places. Hence each year's layer of liber partakes of the character of the stem, not by an increase of number of layers, but by an augmented thickness of each.

The leaves and other appendages of the bark need not be described here; suffice it to notice only, that their expansion is cotemporary with the development of the other parts of the stem mentioned above.

Pendulous stems.—These are commonly called weeping trees; and are exemplified in the *Bètula pendula*, and the *Sàlix Babylònica*. The young shoots, instead of being erect, obliquely or horizontally spreading, droop and hang almost perpendicularly. This is evidently a consequence of rapid growth and constitutional laxity. The erect position of the shoots of other trees depends on their moderate growth and rigidity. Those of weeping trees

have not this stiffness of fibre at first, but gradually attain it as they advance in age; each layer of wood added to the base of the pendent shoot brings it more upright; hence it annually gains elevation: were this otherwise, a weeping willow would never rise from the surface of the ground.

There are many instances of casual flexibility among plants, owing entirely to over-luxuriant growth. Every gardener must have noticed the dangling position of the strong shoots of Jargonelle pear, and other fruit trees. Underwoods, especially of ash, if after they are felled a favourable growing season follows, rarely make straight poles; the weight of the shoots, with their ample foliage, bends them to the earth, from which position they do not soon recover.

Accident has produced varieties of erect-growing trees, which have become horizontal or rather prostrate growers, and art hath perpetuated them. Such are the weeping ash, and one variety of the whitethorn. It does not appear, however, that the hanging position and downward direction of the shoots of these trees proceed from laxity of fibre; because those of the weeping ash, particularly, are as rigid as if they grew upright. Grafts of these grovelling branches continue, though their seeds do not transfer, the deformity.

Climbing or winding stems.—A laxity of stem which would prove injurious to the maturation of the plant, is counteracted by their power of supporting themselves in the air by twisting round any other

plant or slender body within their reach. This is a curious and unaccountable property. If all twining plants revolved in the same direction, something like a rational reason might be assigned as the cause; but, as some turn to the right and others to the left, it is obvious no extraneous agent can affect vegetation so as to produce contrary motions. It appears, therefore, that this tortive action results from a constitutional arrangement of the fibres of the stem, which may be supposed to be conjointly and spirally disposed round the pith or axis, and which, as they are elongated, continue to revolve by their tendency to become straight, while they are lengthened out. We see, at the same instant, an advancing and an involving or retrovolvant action of the stem; and the only explanation of the phenomenon we can give is, that all twining plants, having their system of stem fibres coiled from right to left, turn to the right; and those whose fibres incline from left to right, turn to the left during their growth. All this is assumed as a probable theory rather than a demonstrated fact; for it must be confessed that, except the twisted or spiral position of the furrows on the surface, dissections of these stems have yielded no corroboration of the opinion. The spirally lying position of the fibrous structure of stems, and the spiral vessels found in young shoots, roots, petals of flowers, &c. are evidently organs having a mechanical action to assist in the elongation or expansion of the cellular tissue in which they lie imbedded. In this character these

vessels operate to regulate the expansive force of the distensible membranes of the system under the influence of heat, air, and light. This is not only very visibly the case in twining stems, but also in some others which have aspiring, though not involving, powers. We may instance the larch which, when young and growing rapidly, has not only a wavy* form of stem, which, however, it loses when old, but, when cut up for use, retains this twisted structure so much that it is impossible to keep the scantling in a square or rectangular position, until it has been thoroughly seasoned.

Another remark may be made relative to climbing perennial stems. They are seen to rise perpendicularly so long as they have any thing to cling to; but when they have surmounted the prop their tendency to rise seems to undergo a change; because they never afterwards grow with such rapidity either horizontally or downward, but become bush-headed.

Creeping Stems—are well exemplified in the strawberry and many species of *Gramineæ*.

Progressive growth.—Having noticed the components of the ligneous stem developed in the first year, by which it gains elevation and increased diameter by the inflation of its cellular and vascular

* The structure of the wood of many trees has a wavy character. This is not only visible in the grain of oak and other indigenous trees, but it constitutes the principal value of some foreign kinds especially that called *satin-wood* among cabinet makers.

membranes, each member being impelled into definite order and position according to the natural constitution of the plant; we come now to describe the progressive growth of the second and third years, which with figures of cross and perpendicular sections of the stem in each year, will give as perfect an idea of the constituents and their transformations as the writer is able to convey.

Trees are dormant in winter; throughout that season no change whatever takes place in the disposition of the components of the stem. Every member remains exactly as it was left at the time the growth of the previous year ceased. On the approach of the higher temperature of the spring, vegetable life receives a new impulse, the buds burst their hybernacla*, each shoot is elongated, leaves are expanded, and, perhaps, flowers, and the embryo fruit are displayed. The summer perfects all these, the autumn again arrests the growth, the leaves drop, and the whole plant returns again to its winter repose.

Such as have not produced their seed would, if the summer were prolonged, continue to grow till that purpose of their being took place; but those that have yielded fruit, or passed the period at which it should have been produced, make a pause independent of the heat of the season. The common ash is an instance not only of late vegetation, but also

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* Winter covering.

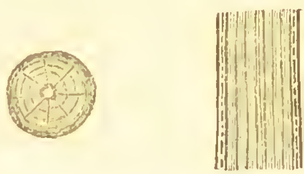
of early stagnation; so that although the genial heat of spring revives the dormant plant by liquifying and giving intestine motion to the sap, yet the continuance of the growth does not entirely depend on temperature. Every hardy plant in this country has only to perfect the shoots, flowers, and fruit which had acquired a certain stage of advancement in the preceding year, and to bring the succession buds to a like stage in this. So in tropical countries the *Enkiănthus quinqueflōra*, and the *Bōmbax ceība* shed their leaves in November, and develope new foliage again in March, notwithstanding the heat of the air is certainly never less than 60°. All this goes to prove that the growth of many, perhaps all, plants proceeds by periodical impulses; their sap being copious or deficient, or transmutable from a thicker to a thinner state, according as the weather, the season, or the state of the plant requires.

When the winter repose has taken place, if we examine a transverse section of the second year's shoot, we find it in every respect like that of the seedling; and if we now look at a cross section of the latter, *i. e.* the first from the seed, we find it composed of a pith, two concentric layers of wood, a new one formed on the outside of the first, and also a new liber formed within that of the first year; the cuticle and epidermis still continuing unbroken on the exterior of the whole. Again, in the autumn of the third year, if we examine a cross section of the third or topmost shoot, we shall find it similar to

that of the seedling already described. The second shoot will be like that of the first in the second year, viz. the pith, two layers of wood, and two layers of liber, covered by the epidermis. And if we cut and examine the bottom, or first shoot produced by the seed, we shall find it consist of the pith somewhat diminished, three layers of wood, and three layers of bark, besides the epidermis. It is scarcely necessary to add, that three seedling plants raised together afford proof of what has just been stated.

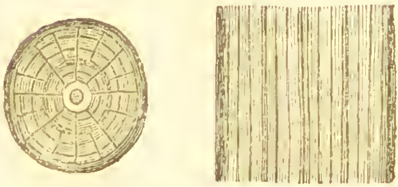
The following are representations of transverse and vertical sections of the seedling stem in the first, second, and third year of its growth.

Fig. 31.



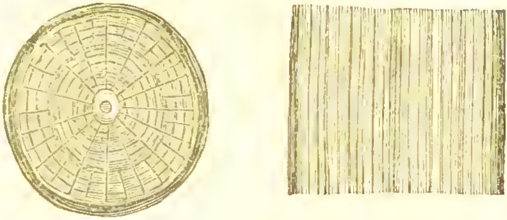
First year magnified.

Fig. 32.



Second year.

Fig. 33.



Third year.

These examples of the annual accretion of the stem for three years will suffice to show the manner of all subsequent growth; for, in fact, an oak of a century old (if not decayed at the heart) will be found composed of one hundred layers of wood and one hundred layers of bark, whether they are distinguishable or not.

The zones of wood are more visible in some kinds of trees than others. Slow growers have their layers so closely posited on each other, that they are very indistinct; and in the case of the oak and some others, they appear twinned or double, owing no doubt to the spring and midsummer growths usually made by these trees. The same observation may be made of the bark; the layers of which are so extremely thin that they are not easily identified.

It often occurs that on viewing a cross section of a felled tree, the pith is not exactly in the centre, where it would be did the tree swell equally all round. This irregularity proceeds from various causes; sometimes from the roots being better

nourished, or from there being more branches on one side than on others. Sometimes the south, in other instances the north side is most prominent. The under side of leaning trees, and of all branches, are extended further from the centre than the upper side*. A wound on one side will determine the greatest share of the growth to the opposite.

Fig. 34.

Example of the manner in which a wound received in the fifth year is healed. A transverse section.

Neither are the annual layers equal in size; some are thicker than others; caused, no doubt, by uncommonly favourable seasons; a tree makes more progress in a moist and warm summer than in one that is cold and dry. There is also difference in the thick-

* This is attributed by some physiologists to the effect of gravitation on the fluids; others imagine that the upper side being more exposed to air and light, the sap is thereby exhaled away more rapidly, and consequently the tubular structure is less distended.

ness of the layers according to the age of the tree; when very young or very old the layers are less than when the tree is in vigorous youth.

From the time each individual layer comes into visible existence till the period of its decay, it undergoes some very material changes. When first visible it is called *càmbium*, and next alburnum by botanists; and by woodmen and carpenters the sap-wood. In this stage it forms the principal channel for the flow of the sap; but after a certain, or rather an uncertain number of years, it becomes changed in colour and consistence, and henceforth is called perfect or heart-wood. In some trees, as the beech, the wood soon gains perfection. The oak has generally six or seven, sometimes more, layers of alburnum or sapwood, and all the interior perfect.

The change appears to be caused by the white wood gradually ceasing to be a channel for the conduction of the sap; and to a certain chemical action by which its colour and texture is changed from a white and soft, to a brown and harder consistence. The sap also, which becomes secreted in the intercellular spaces and vessels of the mature wood, assumes a concreted form and acts as a cement to the fibrous structure.

As different kinds of trees have wood of very different degrees of hardness and durability, the following questions occur; does the durability depend on the texture or density of the ligneous structure, or on the quality of the concreted juices therein

contained? It is said that if Brazil wood be deprived of its colour by any solvent, it loses also its strength and ponderosity. In the case of fir timber, it is very evident that its durability is entirely owing to the resinous and slowly exhalable quality of the sap. Many kinds of timber, as beech, for instance, if kept constantly under water, so that its natural sap be not dissipated, will last for many years. Ash, when arrived at maturity, is as tough under pressure, and solid under the tool as the oak; but it decays much sooner in the air; the durability of the latter must therefore depend on some inherent quality not possessed by the former. Now as the oak contains an extraordinary quantity of an astringent principle, may not this be the preservative matter? On this point an inquiry should be instituted, whether that scantling of oak containing the greatest share of this astringency be or be not more durable than a similar scantling containing less. Another inquiry should be made; whether one description of soil produces oak timber of superior quality as to durability than another, and what is the difference of these soils. It is well known that the most stately oaks grow on deep loam reposing on a clayey subsoil; but the durability of the timber, and the constituents of the soil, have not been, perhaps, sufficiently compared. Some soils are bland and composed of simple earths; others, viz. clays, loams, and gravels, are strongly impregnated with *ferruginous qualities*, which may

materially affect the properties of the timber produced upon them.

For several years past there has been great complaint of the deterioration of oak timber, especially in the dockyards. Compared with oak beams in ancient buildings, that of modern growth is absolutely worthless, falling a prey to dry rot before the ships built of it have been launched from the stocks! Its inferiority has been attributed to want of age, to artificial cultivation, to want of seasoning, to the wrong variety being planted, and to the more general prevalence of dry rot. Whether any of these circumstances may have been the cause of the deterioration, is not clearly ascertained; but it is more than probable, that the quality of the soil whence the trees have been felled, if duly investigated, would show the true reason of the deterioration.

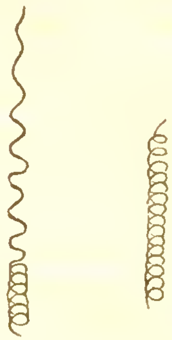
The layers of many years form aggregately the body of timber which, in all its stages, has an obvious longitudinal arrangement; splitting most easily from top to bottom, and in right lines through the pith; and also readily in the direction of the sides of the layers, which separate from each other with ease. These concentric layers are only attached to each other by fine cellular matter, but without any interjunction of their fibres; the diverging partitions, which proceed in right lines from the first layer to nearly the outside of the bark, appear to be the connecting ties which keep the whole together. In

whatever way the wedge is introduced, it is the cellular matter that yields in the cleavage. By no power can the trunk be cloven transversely; the fibrous structure opposes all efforts to separate the wood across its position.

The longitudinal strength, common to all woody stems, appears, however, to be in some plants acquired by age. The grape vine is an instance among trees of a peculiarity in the structure of the stem when very young, namely, that the longitudinal arrangement of the fibres is interrupted at every joint, parting easily at the nodes, leaving a clean surface on both divisions. This shows that the first layer of wood is somewhat articulated, and has less longitudinal connection and tenacity than those which are afterwards imposed.

The woody fibres which give strength and toughness to the layers are united irregularly with each other; in young shoots which have just commenced growth, some of the fibres, especially in the medullary sheath, are seen disposed in single or double coils, which become almost straight when lengthened out in the growth, and the whole then appears (when the layer is split through the middle downwards) like the meshes of a net, when intensely stretched in one direction. No spiral vessels are found in perfect timber; because the single or double fibres which formed them are then disposed at full length.

Fig. 35.



Spiral fibres found in young shoots, petals, and points of some roots.

These spiral vessels, or rather ligneous fibres spirally disposed, being seen only in young shoots, leaves, petals, &c. which are in the act of elongation, and never after the longitudinal growth is over, may be conceived to act mechanically, as before observed, in the evolution of the shoot ; or, if not, we must admire the natural disposition of a fibre, of perhaps a foot long, so coiled up in a bud before its expansion.

If we examine a single fibre with a glass we gain no very clear idea of its conformation. However carefully separated from the mass, there remains adhering to it a crust of the cellular matter which unites the fibres together, so that its structure is thereby obscured. But it evidently has an identical character, of which its toughness and elasticity are sufficient proofs. Physiologists who have employed micro-

scopes of the highest powers, describe the ligneous fibres as being formed of "elongated cells attached by their ends to each other."—*Solly.*

The Sap.—The sap of plants is that fluid which fills and assists to distend the cells and vessels. It is of various consistence; in some plants it is thin and watery, easily congealed by cold and evaporated by heat; in others gummous, and in many resinous. Besides the difference in consistence, the sap contains many essential qualities, as sugar, starch, resin, &c. with a thousand combinations of these and other bodies in various degrees.

The juices become inspissated and almost stagnant during winter or when the plant is at rest, and regain fluidity and motion on the return of spring, or of the growing season. So completely fluid is the sap soon after the commencement of the growth that it flows freely from wounds. During summer its excess is consumed by the lengthening shoots, numerous leaves, and swelling fruit. In autumn it becomes gradually thickened in consistence, and is at last again arrested in its motion by the cold of winter. It is often observed, however, that in the last mentioned season, even after the leaves of deciduous trees have fallen, and all outlets of the growth shut up, that a few warm days will so liquefy the sap, that it will again flow from wounds; more especially if the roots are in a moist situation.

That the peculiar qualities and characteristics of the sap are elaborated by the plant itself, as has been

before asserted, is perfectly notorious. To no purpose do we analyse the soil in which it grows, or the water with which it has been nourished, to detect the qualities which are found in the root, stem, or leaves, much less in the fruit. It must be remembered, that in the areolated structure of vegetables all the apparatus of the chemist's laboratory are found: alembics, retorts, and all the natural machinery for absorption, filtration, condensation, and assimilation of aqueous, vaporous, and gaseous bodies of the earth and air, are silently and constantly in operation, and the results are the production of the essential qualities of the plant.

In all the living members of a tree, as in the seat of life, the recently formed layers of liber and alburnum, the sap is capable of motion; but in those members which have already performed their functions, and acquired form, namely, the outer bark, and first formed layers of wood, it becomes concreted and stationary. While capable of motion it usually ascends, is transpirable, and consequently exhaustible. In the latter case, the leaves and tender shoots become flaccid and shrink; but when the exhausting cause is withdrawn, or a sufficient supply of water is received by the root, the shoots and leaves quickly regain their rigidity and vigour. This single incident is a convincing proof of the ascent of the sap; nothing indeed can be more manifest.

That the repletion of the sap vessels is kept up by the agency of the roots and other absorbing organs of

the system, scarcely admits of doubt. The ascending current may be exhibited to the naked eye by the well known expedient of supplying roots with coloured liquids, as has been proved by Darwin, Knight, &c., and every florist knows that the colours of flowers may be changed, and the bulk of all the parts increased, by the application of suitable manures.

Much ingenuity has been shown, and the most laboured philosophical dissertations have been written, to account for the ascent of the sap, one of the most simple processes in nature. For surely, if a bit of sponge, or any tissue of filaceous matter be capable of imbibing water to any height, no doubt need be entertained of the power of vegetable organisation, with its myriads of cellular and intercellular ducts and tubes, to do the same. The elongation, distension, or inflation of any tube, cell, or vessel, in the extended head, must necessarily produce a vacuum which is instantly filled up. The pressure of the atmosphere, capillary attraction, or simple imbibition of areolated substances, are all ordinary agents capable of effecting this result. The like effect takes place in an *old oak gate-post;* and why should not the hydraulic action of the extending shoots, the perspiring leaves, and the craving fruit, produce a similar result in living plants? It would be a waste of time to insist farther on such an obvious truth; for, in fact, the ascent of sap may not inaptly be compared to the common evaporation of all fluids under the action of heat.

It has been observed above, that after an uncertain period portions of the trunk cease to partake of the diffusive current of the sap, and in those effete members it becomes concreted. In this state it is very visible in fir timber, reposing in knots and flaws, and oozing out of the pores, when exposed to heat. When chips of wood are submitted to maceration in a proper menstruum, the secreted sap is first dissolved, next the cellular partitions, and at last the woody fibres are decomposed *.

Although the natural motion of the sap be from the roots to the extremities of the branches, there is no doubt of it being occasionally transfusible in all directions. Wherever there is depletion, thither will the current be drawn; whether that be upward, laterally, or downward. Whatever the position of the branches may be, we see the sap courses along them to reach every extremity.

With respect to the old popular belief that the whole body of sap regularly and annually retires to the roots in winter, there to remain till the genial warmth of spring again prompts it aloft, we may observe that the doctrine rests on no very solid foundation. The vessels of the roots are never at that season so destitute of sap, nor have they capacity

* In the case of pine or fir timber it is observable, that where the cellular structure is most dense, as on the exterior sides of the concentric layers, these portions are more durable than the intermediate spaces. The medullary rays of these trees, though numerous, are extremely thin.

enough to admit such a surcharge. The sap in the branches is not visibly diminished by this supposed subsidence; and what is more against the idea than any thing else, *is the stubborn fact,* that the motion of the sap begins at the top of the tree before it is at all liquefied at the bottom, which could not happen did the returning tide flow from the roots. The best argument in support of the subsidence of the sap is that used by the carpenter respecting the quality of winter and summer felled timber: but this will be answered under the section *Felling.* We may, however, observe here, that if there were any apparent necessity for such subsidence we ought, unhesitatingly, to concur in believing it. We are well aware that those who believe that the elaborated sap descends, also believe that it is chiefly disposed of in the formation of the new zone of wood along the whole length of the stem and roots; so that the carpenter's idea of it all sinking to the roots is abandoned: but, if our eyes have not greatly deceived us, we have observed that this same new zone of wood is formed and replete with sap, before the time arrives at which the sap is said to take its downward course. And, indeed, except in the case of herbaceous perennials (admitting the opinion true with respect to them) it appears to us, that the subsidence of the sap, in other cases, is superfluous, and contrary to the usual operations of nature.

Upon the whole we are led to conclude that the sap is composed of fluids chiefly imbibed by the roots;

that its specific qualities are acquired from the pre-existing essentials of the plant, and from the elaborating powers of the organic structure under the action of air, light, and heat; that, whether as liquid or as vapour, its motion, generated by heat, must necessarily be upwards, if not impelled or attracted in any other direction. Whether it be capable of sinking by its own weight is, perhaps, questionable; because there must be a vacuum somewhere to receive it, or it must displace some other fluid which must ascend out of its way, and the tubes containing it being all sealed at the top, prevent the perpendicular pressure of the atmosphere; and though true, that when abundant and fluid, it distils from the upper side of a wound as well as from the lower, yet it continues to ooze away from below longer than it flows from above, whether the wound be made in the spring or in the autumn. Example, a felled tree: while the dissevered butt of the stem is quickly dried, the root remaining in the ground, will continue to bleed for months after the separation. The sap, therefore, besides its direct motion, is capable of being diffused through the whole body of cellular and vascular matter, and of course flows towards any outlet, whether that be aspiring shoots, perspiring foliage, swelling fruit, empty vessels, or bleeding wounds*.

* A curious instance of the counter currents of some component of the sap is observable in the common aquatic plant *Chàra*. Bright globules are seen to rise and fall in the vessels, exactly similar to what is seen in fermenting liquors.

Like other fluids the sap of trees flows quickest in right lines. This is well known to the pruner and trainer; who, by curving or reversing the leading shoots, checks their luxuriance. It flows, however, with greater celerity perpendicularly than in any other direction.

While the sap is stagnant in the branches, it is also so in the roots, but with this difference, that in the latter it is always fluid, owing to the higher temperature of the soil, and consequently, is ever ready to rise as soon as the channels in the stem are open. In mild winters (perhaps in all winters) there are signs of life visible in the slowly swelling buds, and exsertion of new fibres from the roots.

The sap has been supposed to be transmutable into cambium, and ultimately into wood; but this requires confirmation; because, if sap be exuded from a wound, it takes either the appearance of gum, as on the cherry, or sanies, as on the elm; but, when cambium is protruded into air, it immediately assumes a ligneous character. Besides, if sap be capable of transmutation so as to be indurated by chemical agency into timber, why is it not seen to be so changed in the interior of stems, where it is found hardened indeed, but perfectly homogeneous and free from every sign of organisation? It is said that elaborated sap descends from the leaves down the bark, and is thence attracted inwards to the centre of the tree; but this being an invisible process and caused by agents unknown to, and out of the reach of, mere

practical observation, disqualifies us from either assenting to, or denying what can only be a plausible supposition. It is also said that flowers and fruit are formed from accumulations of elaborated sap. For instance, if a tree, or a branch only be "ringed," the matured sap thereby pent up and prevented from sinking to the lower parts, is expended in the production of flowers and fruit; thus attributing to the sap the property of conversion into organs. Were it only inferred that perfect juice is necessary to the sustentation and expansion of flowers and fruit, the idea would be reasonable; but that organic structure can be spontaneously formed from a mere fluid is wholly incredible.

The foregoing observations concerning the properties and motions of vegetable sap, being very different from the usual notions entertained of it, the writer hopes to be excused if he occupies another page or two of remarks, by way of justification of himself for thus differing so much from the opinions of his cotemporaries and professional brethren on this important part of vegetable physiology. A full explanation is the more necessary on his part, because the belief of the annual descent of the sap is not only, as before observed, a very old idea, but also because it serves to explain several circumstances occurring in the growth of plants, which cannot be otherwise accounted for. The writer does not deny the possibility of occasional or partial sinkings of the sap; on the contrary, he is fully convinced of its

diffusibility through the cellular and vascular structure in all directions ; but that the sap should retreat iu a body from one set of vessels, which, notwithstanding, are not emptied, and proceed to others that are already full, is extraordinary ! If we consider the motion of fluids in general, and in all ordinary circumstances, we invariably observe that their motions are caused by their fluidity, ponderosity, or temperature ; if they flow from a place which is full, it is because there is a vacant space to receive them : a rarer fluid will give place to one that is heavier ; and consequently the warmest parts of a fluid will rise above those which are colder. But in all these cases an outlet or vacuum must exist, or the removal of some pre-occupying fluid must take place before any motion can be generated. Now, we presume no practical eye has ever discovered that roots are more charged with sap in winter than they are in summer, nor that the topmost shoots are sapless during the former season. If it be urged that the lower temperature of the sap in the branches is the cause of its subsidence to the roots, it may, with equal reason, be asserted, that the warmer portion in the roots will be propelled aloft by such subsidence, and that an equilibrium will be always maintained. But it is further quite manifest, that if there be any descent at all, it not only takes place in the autumn, but is in operation all the summer ; because one of the principal proofs of the descent of the sap, namely, the swelling of a stem above a ligature, becomes

apparent early in the summer, and therefore is as valid proof of descent in the month of May as in September or October. Bulbs, tubers, and tuberous roots begin swelling early in the season, and continue increasing till the growth ceases in the autumn: consequently there must be *something like* a current down as well as upward. This is, however, one of the most inexplicable phenomena in vegetable economy.

It is quite evident that all the parts of a plant, root, stem, and head, are enlarged together during the summer, and mainly by the nutriment taken in by the roots, and which food, of course, ascends to the parts above and descends to the parts below the roots, as in the case of potatoes. In watching the gradual enlargement of the stem, we cannot avoid observing, that there is a processional maturation or enlargement of the parts, beginning, as it were, at the top, and proceeding downward, not only to bulbs and tubers, but to the fibrous roots of trees also.

In order to have a clear understanding of this curious circumstance, it is only necessary to state the facts as they occur to practical observation:—If a shred remains too long in the same place on the stem or branch of a trained tree, it causes constriction, which not only obstructs the growth of the part covered, but produces an unnatural prominence on each side of the band, and much more above than below. (Fig. 36.) This result shows that some component or internal motion of the plant is obstructed

Fig. 36.

in its course from the extremity of the branch to the root. Similar protuberances are found at the lower end of a graft or bud that happens to be placed on a stock of more diminutive organisation. (Fig. 52); also

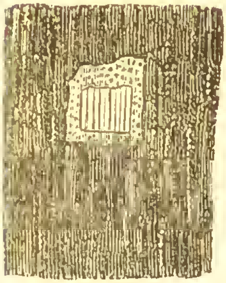
Fig. 37.

above the base of every branch of a tree ; or round a place whence numerous shoots have been repeatedly browsed off (Fig. 37). Beech and elm trees frequently present malformations of this kind; sometimes by large tumours formed within the bark—united to, and being projecting parts of, the woody axis, and occasionally by insulated portions of ligneous matter involved in the bark and easily separable therewith. The same kind of protuberance is often formed at the base of cuttings previous to the ejection of fibres (Fig. 38) ; and also round a wound on a

Fig. 38.

stem, particularly at the upper side (Fig. 39). Such accidental eruptions on old trees continue to be enlarged for many years, and receive annual additions of bark and wood, like any other part of the trunk ;

Fig 39.



their form being generally oblongly round, but increasing *downward* much more rapidly than in any other direction. (Fig. 40.)

Fig. 40.

A protuberance on an elm.

When these protuberances are laid open, we find them composed of either cambium on their first appearance, or of ligneous material after they are six months old; and evidently dilatations of the vital

envelope. Some former, and many modern, botanists consider these callosities as no other than obstructions of the returning sap; others conceive that they are fibres projected from the buds and shoots above, which are arrested in their progress down, and accumulating above the constriction cause the distortions in question.

From many and repeated observations made on the effects of ligatures on various sorts of trees and shrubs, and daily in view for several years past, it is quite evident, that the swellings, both above and below, begin to be visible very soon after the spring growth commences; and that they appear to be nothing more than that part of the vital membrane confined by the band, venting itself above and below, and forming the protuberances alluded to. If a single wire be used, the swellings on each side are nearly equal: if the band be of the usual width of a shred, the prominences on each side are nearly equal on some trees, but on others that on the upper side is considerably larger than the one below. (Fig. 36.)

It is quite obvious, that if there be a procession of either sap or fibres from the superior to the inferior parts of the stem, a ligature would certainly produce a swollen margin on the upper side; and did the tumour at any time of its growth contain simple sap only, no doubt would remain of the cause; but this is never the case; the interior is invariably found to be either imperfect or perfect wood, that is, either cambium or alburnous matter. This, indeed, to those who believe that the sap is "organisable," is no

mystery; but as it is easily proved that cambium and sap are two very different components of the plant, and moreover that no direct proof has yet been had of the descent of fibrous matter from the buds downward, we are compelled to pause before we can confidently ascribe the cause of the tumours to either the descent of the sap, or to ligneous fibres from the superior buds.

But if neither sap nor fibrous matter produce those appearances, what else can it be? We have already said, that the circumstance is inexplicable; and it would be uncandid and inconsistent with our regard for truth, did we not frankly acknowledge our inability to explain the phenomenon. Mere suppositions would be impertinent; and it is every way better to leave such a matter open by recommending it to the consideration and scrutiny of others, than obscure it by fanciful conjectures.

The only circumstances which appear analogous to the downward action observable in this case, are, firstly, the manner of flowering of the genus *Liàtris*, and some other plants. Instead of the flowers opening from the bottom of the stem upwards, they begin at the top, and blow consecutively downwards. Secondly, the culms of wheat, and other corn ripens, or rather dies, from the ear downwards; so that the seeds are ripe before the vital action ceases at the bottom, and whilst the crown is yet throwing up fresh stems. Thirdly, the spring motion of the sap begins at the points of the branches. This fact has led some most

intelligent practical men into error; they conceiving that instead of the sap rising, as it is known to do, it actually descends! Now, a moment's consideration might convince them of their mistake. The sap undoubtedly begins to be fluid and first in motion at the top of the tree; that immediately below is next liquefied, followed by that lower still, and so down lower and lower till the whole—that in the root also—is in full motion. We have elsewhere (*Gard. Mag.* vol. vi. p. 214), compared this circumstance to the sudden opening of a full canal at one end: thus opened, the water flows out; the current begins at the outlet, and is generated backward till the whole is flowing. This is exactly similar to the first spring movement of the sap of trees, and presents the appearance of a motion directly contrary to its true course.

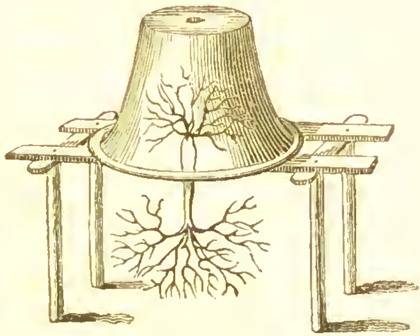
Whether the maturation (if we may use the term) of the cambium into alburnum, in the latter end of summer, takes place in the same order, that is, beginning at the top and ending at the root, remains to be proved. The fact of roots being more enlarged during autumn than at any other period of the year, is some corroboration of the supposition; still the question is not free from doubt; because the idea presupposes that this change of cambium into alburnum is only a *descending effect*, not a positive progression downward of any actual member or component of the tree, and therefore unsatisfactory, unless we could prove that the full expansion of every inferior cell depends on that of the one immediately

above it. Besides, if this downward motion be only that of an effect on the cellular structure, why should a bandage prevent the expansion of the structure of the stem, as well *below* as *above* the band?

The subject is every way intricate, and requires investigation. We have made many experiments to ascertain the cause, but without success. All our conclusions have been negative rather than affirmative of what we expected—what it is not, rather than what it really is. For instance, we observe that the new zone of wood formed in the course of summer, begins to be visible at the bottom of a lofty tree nearly as soon as it is on the highest branches, though we cannot vouch for its being as soon perfect. This being the case, we doubt whether any fibres specially attached to, and descending from, the expanding buds and lengthening shoots, can possibly reach so far down the trunk in so short a time as elapses between the bursting of the buds and appearance of the new alburnum so far below; nor can we admit that there is any gradual descent of fibres in the course of several years—that is—those belonging to the buds of 1827 gaining, or reaching to the base of the trunk in 1831, or in any subsequent year. We know this to be impossible, as will appear by referring to Fig. 48, page 145. Another thing—the longitudinal connection and arrangement of the fibrous structure of each zone of wood, is so entire from top to bottom, that, on examination, we can arrive at no other conclusion than that the whole is simultaneously produced.

We are authorised to state the result of an experiment which we had the pleasure of witnessing two years ago, viz.:—Mr. Knight, of the Exotic Nursery, King's Road, Chelsea, believing that the sap, after being elaborated, obeyed the law of gravitation, and in subsiding caused the swellings on strangulated branches, fixed ligatures on the stems of a good many plants in pots, which were reversed on a stage made for the purpose.

Fig. 42.



In this unnatural position the plants grew well: the swellings, however, caused by the bands, were on the same side as if the plants had stood upright, namely, on that nearest the top, showing, as Mr. Knight properly observed at the time, that the prominences are caused by some internal movement or constitutional power of the plant entirely independent of position.

The effect, whatever may be the immediate cause

of these protuberances, is evidently similar to those callosities formed at the base of cuttings, and therefore it may be said to be an effort of the vital envelope to produce new roots, instead of those from which the communication is partially cut off by the ligature. But admitting this, we are still in the dark respecting which component it is that is thus obstructed in its course. We might, indeed, bring forward a very plausible idea of a modern writer to account for this processional movement down the stems of trees, which he attributes to the descending "electrising principle of the sun's rays;" but we fear to quote, lest we should err in referring to what we do not clearly understand.

The seat of vegetable life.— Every developed member of a tree is imbued with the vital principle in its early existence, and retains it while in the act of expansion, but no longer. The bark is an exterior, and the wood an interior increment; both have been inflated into form, and forced into position by the life; but as soon as the form is complete, and the position imposed, they are deserted by it, and when they cease to partake of its influence entirely they succumb to decay. Nothing shows the truth of this more decidedly than the circumstance that if a tree were divested of all its coats of bark but one, viz. the liber, it would continue to live and even prosper; and were it possible to take out from a trunk the pith and all the concentric layers of wood save one, viz. the alburnum, the tree would nevertheless continue to live

and increase in size, though the cavity would never again be filled up.

There are, therefore, it is necessary to repeat, two states or degrees of vegetable life which should be described in order to be distinguished from each other, to avoid confusion of terms or ideas. The first is always present in those members which are capable of amplification, or are in the act of accretion, *i. e.* expanding from a small to a larger volume. The second is that state in which it is only conservative, but without the power of further growth of the members preserved by it. The first it is deemed proper to designate by the name of *vital envelope*, whence proceeds every new member of trees, shrubs, and many herbaceous plants. The second is that state of the bark and alburnum which, having but recently come into full form and magnitude, serve as conductors of the fluids of the system for a certain time, but from which the actual life has for ever fled.

Where then does the living principle reside? In the pith? no: in the wood, or in the bark? no, in neither of these, but it is always found at all times between the liber and the alburnum, slightly attached to both, but united to neither: it is reasonable, therefore, to conclude, that it is a *distinct member* of the system.

Of these opinions it is necessary to bring forward proof; and in order to do so satisfactorily, we have only to trace the phenomena of vegetation through the spring and summer growth of a tree of a few years old.

The growth of young shoots and their components has been already described; here we are about to attend to the manner in which this takes place. On the approach of the vernal warmth, the first sign of vegetation is observable in the swelling buds. At this time the sap which, for the most part, remained in a motionless and inspissated state during winter, becomes fluid and readily flows from wounds made through the bark. The narrow space between the alburnum and liber contains a copious flow; the latter appearing completely separated from the former. Soon afterwards, as the season advances, shoots are prolonged, and the foliage expanded; the sap flows less freely from wounds; a new body becomes visible in the space before mentioned, and begins to assume a lymph-like state denominated *cambium*. In this substance there is yet no appearance of organisation. The organs are then so diminutive and colourless, that neither their form, relative position, nor attachments can be detected, even with the assistance of the microscope. Mean time the bark is obviously giving way to the expansive force of the swelling cambium, and towards autumn, when the growth becomes languid, the cambium has acquired considerable consistence; the organisation is now visible, and very soon assumes all the appearance of perfect alburnum. At this time too, we find, that a new liber is separated from the new body of alburnum, and remains closely pressed against the liber of the former year.

Now, whence have these new layers of wood and inner bark derived existence? They are not a dilata-

tion of the last year's alburnum; because that remains precisely of the same form and dimension it had at the end of the preceding year. Neither has it sprung from the liber; because that also remains unchanged, and is in fact superseded by the new one within it. As then they are not parts of the members with which they were and are in contact, they must either be self-generated from the fluids of the system by the assimilating powers of the plant, as has been by many supposed, or from some vital member which has been hitherto overlooked, or probably misnamed by physiologists.

That such organised matter as that of bark and wood can be formed out of any possible accumulation of gaseous, aqueous, gummous, or even resinous fluids, or from their qualities, is extremely questionable. We cannot conceive that the beautiful arrangement of fibres, tubes, cells, and all the other structure of the vegetable fabric can receive specific disposition fortuitously. There must be a pre-existing organised body whence such regular formations proceed.

The beautiful forms and results of crystallisation are indeed astonishingly admirable; but they are generated by chemical associations, and obey other laws than those which govern vegetable development. That chemical agency is present in all vegetable processes is very probable, not, however, in such potency as to create forms and vital substances, farther than assisting the exhibition of them.

It may be concluded, therefore, that the new layers

of bark and wood proceed from a member which, from its having been erroneously identified with the liber or alburnum, has escaped observation merely from its unobvious identity, and the small space it occupies in its dormant state. It may be best distinguished by considering it as being the inner viscous lining of the liber, and in this position and character it appears during winter as a very thin layer, scarcely distinguishable from the liber itself.

That this thin body or *indusium* is really the seat of life, the following circumstances may be urged as proof; and as they are constantly occurring to the practitioner in the propagation of trees, are the more to be depended upon.

In the first place we may notice that no fibrous roots are ever produced from the wood or bark in any stage of their existence; nor do buds ever originate on the bark or wood, except from the first layer which surrounds the pith in the first year of its visible existence; and which layer, be it remembered, is then in the act of swelling into form, and consequently part of the vital envelope. If a cutting be put in the ground, the first change it undergoes is a visible protrusion of cambium from *between the wood and the liber*, and from which in a short time fibres are exserted that become roots. So in the case of layers, the roots all proceed from those parts of the incision where this living member is exposed; and even where no incision is made fibres will be produced, apparently from the bark, but, in fact, originating

from its inner surface. When a bud or graft is placed in or upon a stock, it is the interjunction of the member between the wood and the liber of each which forms the union.

As this vital member is the depository whence all roots proceed, so is it the seat of all incipient buds, and even of flowers. When the *Cercis siliquàstrum* has a branch pruned off, the wound is healed in the usual way, not by an extension of the old bark or liber, but by the vital envelope gradually closing over it; and during its progress perfect flowers are ejected from it as well as from the clefts of the old bark. Buds we often see sprouting from the fissures of the bark of old trees, or brought out by pruning or decapitation. A truncheon of a willow placed in moist soil, a cutting of a myrtle, or a piece of the root of whitethorn, planted in favourable circumstances, will all produce shoots from the latent buds contained in the vital envelope. In short, no accretion whatever appears, or possibly can appear, of any other member of the plant, save from that one we have endeavoured to describe*.

It is further manifest, that this slender body of

* As further proof that buds originate in the indusium, it may be remarked, that, in the case of hollow elms, if the wood be entirely decayed, and part of the last-formed layer of alburnum removed, so as to expose the interior side of the vital member, inside shoots will be produced therefrom, and rise within the hollow trunk.

vitality is constitutionally compound, not simple, as such a thin tissue may be supposed to be. That it is annually divided into three portions is perfectly obvious by ocular demonstration. In early spring it is a thin layer, in the autumn this same layer is divided into alburnum, liber, and the remains of itself. It is, moreover, subdivisible into separate small parts longitudinally, each of which contains the specific essentials of the whole, namely, the formation of bark and wood, and the rudiments of roots and shoots.

This last assertion is verified by what is often seen on the surface of the alburnum of a decorticated tree. The surface of the alburnum is unequal; it is varied by little furrows or crevices, and which, when the bark is stripped off, retain, in some instances, small portions of the envelope. These insulated portions, however, soon show their vital property by swelling from their stations, and by spreading themselves over the naked wood, assist materially to close the wound.

The foregoing observations are intended to support the idea, not only of the identity of the vital envelope as a distinct member of the system, but also its compound character as containing the rudiments of both roots and buds; and, moreover, the source of all accretion, whether as to the magnitude or number of the parts produced.

That a finite quantity or number can be infinitely divided has always been a mystery, except only to

the geometrician or mathematician; and to suppose that a like property is possessed by any member of a plant is equally mysterious. Yet something of the kind must be admitted before we can rationally account for the interminable reproduction of perennial plants, or of the endless division of parts of plants.

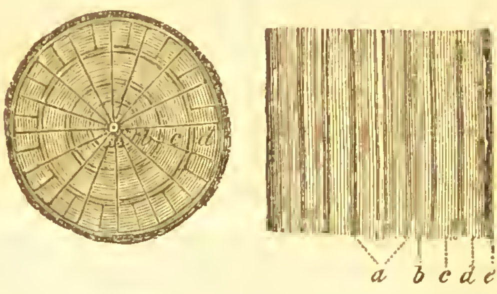
The foregoing idea of the existence of a distinct vital member, whence all new accretions proceed, is directly opposed to the modern doctrine of the "organisable property" of the elaborated sap of plants. The idea is founded upon the general law of vegetable nature; for where do we find the most insignificant vegetable body come into visible existence without having a pre-existing embryo or rudimental atom, whence it derives its essential structure and qualities. There is no such instance in nature. Can the most minute species of *Fungi* spring forth without its propago, or the smallest herb without a seed, or previously existing part of itself? Is the bark or wood self-productive? No: when either is destroyed it cannot be renewed but by the assistance of that vital member which is the origin of both.

Admitting, then, that plants and certain parts of plants possess the property of perpetual reproduction and extension, a question follows: How is this subdivision effected? In the case of bulbs it has already been stated, that the radicle plate is composed of an endless train of gems, which are developed in the order of their seniority; tubers are multiplied by

division or branches ; fibrous-rooted herbaceous plants perpetuate themselves by lateral offsets; but how is the annual subdivision of the vital envelope of trees accomplished ? To this question a direct answer cannot be given, because the process is invisible ; but we can gain a knowledge of the changes which take place between the wood and the liber of a tree by making frequent incisions through the bark, and marking the changes during the spring, summer, and autumn growth.

In early spring, say in the beginning of February, the transverse and vertical sections of the stem of four years old appears as represented. (Fig. 43.)

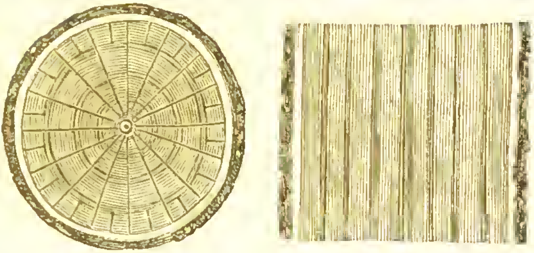
Fig. 43.



Transverse and perpendicular sections of a stem four years old ; the latter through the pith. *a*, pith and wood of the first year ; *b*, *c*, *d*, layers of wood of the second, third, and fourth years ; *e*, the four thin layers of bark.

About the end of May, sooner or later, according to the favourableness of the season, similar sections of a stem of the same age will appear as Fig. 44.

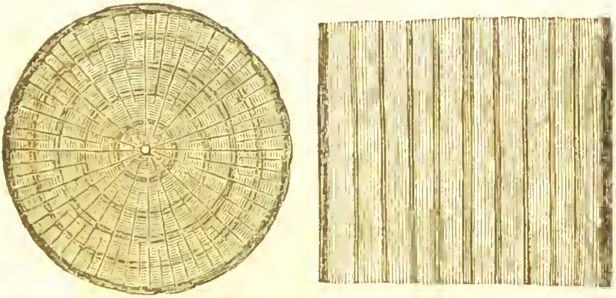
Fig. 44.



Sections of a stem as it appears in May or June of the fifth year. The white spaces show the swelling cambium.

At the end of September, and in many kinds of trees much sooner, the sections appear as in Fig. 45.

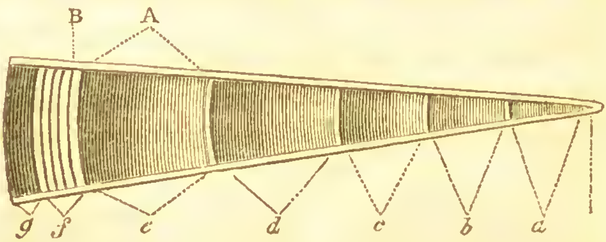
Fig. 45.



Sections of a stem at the end of the fifth year. The envelope and layers of liber are too thin to be shown by the pencil.

Here we observe that a new concentric layer of alburnum has been added during the fifth summer, and also an additional layer of liber has been parted off, and placed close to that of the preceding year, and lined on the inner side with an almost imperceptible membrane or coating of gelatinous matter, which is the vital envelope, and from which the new growths of wood and liber of the next, and all succeeding years will be produced.

Judging, then, from these changes, about which there can be no doubt (because of them we have ocular proof), we may conceive *that the vital envelope is constructed of an indefinite number of distinct concentric layers, two of which are developed annually;* the inner one (A, Fig. 46) being inflated into alburnum, and the outer one (B, Fig, 46) into a layer of liber.



Segment of a transverse section of a tree five years old, magnified: *a*, growth of alburnum first year; *b*, the second; *c*, the third; *d*, the fourth; *e*, the fifth; *f*, five layers of liber, ideally magnified; *g*, epidermis and cuticle.

The appearance of the structure of the alburnum affords confirmation of the reasonableness of this idea. If we examine it as soon as it is formed, or in any future stage of its existence, we find the longitudinal fibres strongly and distinctly marked, and the minute vesicles of the cellular fabric between the fibres posited *horizontally;* showing that they are enlarged in the same direction—that is, advanced from the centre of the tree outwards. (Fig. 2.)

This hypothesis is only objectionable, perhaps, on the ground of the difficulty of conceiving how such a mass of organisation, forming the extended trunk of a full grown tree, can be contained in such a slender space as that between the liber and

the wood of one of four years' growth. But this difficulty is not greater, indeed not quite so incomprehensible, as is the other supposition already alluded to, namely, that all increments are elaborated from juices and qualities inherent in the plant; or formed by accidental associations of certain electro-chemical bodies extractable from the earth, air, and water. The identity of the vital envelope, during summer is visible and palpable; and if in winter it be only a cincture of transparent cellular matter, no doubt need be entertained of its subsequent expansibility. That vegetable matter appears in the first stage of its existence as a colourless homogeneous mass is indisputable; and that it gradually gains consistency and organic form, may be easily believed by examining an orange when first visible in the flower, and again when fully ripe and deprived of its juice. Besides, the accrescent powers and indefinite limits of vegetation in this case, should banish incredulity; in many other instances it is equally surprising; witness the monstrous gourd, the majestic oak, the magnificent *Banyan Fig;* the latter shading acres of surface, all originating in an atom of a seed.

The new layer of wood which is added on the old stem or trunk, ranges with the first layer of wood on the terminal shoots. On the latter all primary buds, and consequently branches, originate. The shoots developed this year, except water shoots*, are based

* Water shoots are such as are produced on luxuriant growing shoots of the present year, frequently seen on the peach, apricot, and always on the grape vine.

on the alburnum formed on the last; and the buds formed in this year are seated on this year's alburnum, and on which they remain to be developed in the next or some following year. The pith, wood, buds, and bark of every shoot are all simultaneously produced.

But all buds or branches are not *primary*. Such as are produced from an old stem (*b*, Fig. 47) whether

Fig. 47.

Example of a primary shoot *a*, and a secondary shoot *b*. The former is seated on the alburnum of the first year, the latter on that of the third.

naturally, or by consequence of pruning, may be called, for the sake of distinction, *secondary**. These can have no immediate connection with the first formed layer of wood and pith, and therefore invariably spring from the envelope. The following delineation represents the disposition of the layers of wood and bark, with the places of the primary and secondary buds or shoots, on a section of an abbreviated stem of a tree of three years' growth.

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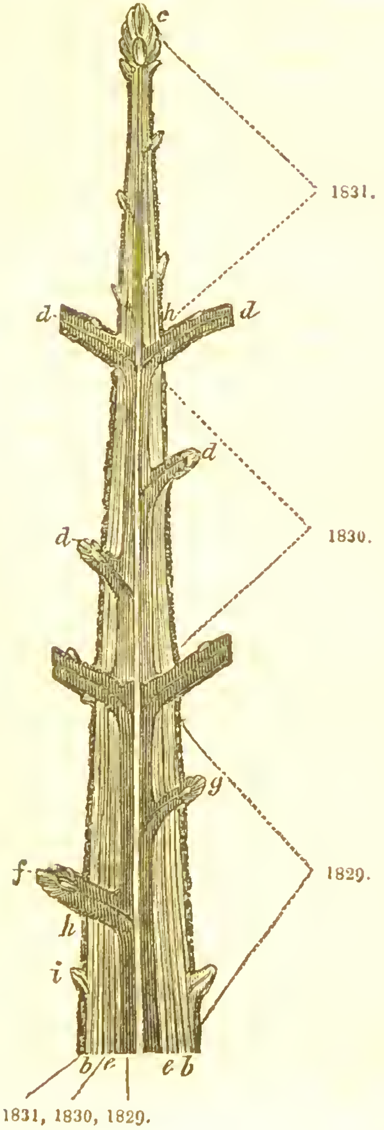
* Botanists suppose that there are what they call "adventitious buds," that is, if buds come forth from other places than the axils of the leaves or bractea, they are adventitious and new creations. Their appearance, indeed, may be adventitious, but not their identity. If a bud can be produced without a rudiment, so may a whole plant.

Fig. 47.



This figure shows, that the lateral shoots, *d, d, d, d,* and new layer of wood, *b, b,* on the lower part of the stem of the present year, are not attached to each other; and that the growth of the former can only affect that of the latter indirectly; nor can they (the shoots, *d, d, d, d,* except the leading one, *c*,) be supposed to assist the formation of the new zone of wood by ejecting fibres *down into it;* because their fibrous attachment is upon the alburnum, as at *e, e,* Fig. 47; that is, upon that division of the envelope which was formed into alburnum in the previous year.

The young shoots which are elongated and bear the foliage of deciduous trees, are pretty regularly studded with buds along their whole length, though only a small number of them are developed in succeeding years. A few at the point always burst, namely, the leader and two or three laterals, part of the latter being resolved into branches. Some of the lower situated are prolonged into spurs, and become flower buds, as at *f, g,* Fig. 47; many remain dormant, and are never developed unless the stem be cut over immediately above their station.

From these circumstances it appears, in respect of secondary or tertiary buds springing from the vital envelope, that that member is possessed of these latent principles, which are put forth when surrounding circumstances favour their development. It was this fact which induced an eminent French botanist to imagine, that vital gems

floated in the sap: for on no other principle could he account for their inexplicable appearance. There are many trees having a fine smooth trunk from which not a spray would be put forth while its branched head remained alive: but on being decapitated thousands of shoots would issue from the bole, even if its pith, and almost all its body of timber had gone to decay; a strong proof that the envelope contains the rudiments or principles capable of being resolved into buds as well as of radicle fibres.

It has been supposed by some physiologists, that the medullary rays are the tracts of buds, and that all buds originate on, or proceed from the pith; but we have no certain evidence of the truth of these ideas; on the contrary we find, that buds of many kinds of trees issue from roots where pith has never existed; and medullary rays, or partitions rather, are abundant where no buds are ever or can possibly be produced, viz. on the internodes of jointed stems; example, the grape vine. And it may be further observed, that in the plant just named the greatest number of shoots, in fact every shoot, is ejected from the articulations where the pith is visibly interrupted. Of what are called medullary rays, we may observe further, that though known by this name, they do not all take their rise from the pith: as the stem increases in diameter, intermediate partitions come into existence at different distances from the centre, and appear to originate in the bark rather than in the pith.

This view of the constitution of a tree shows us that it is not, as usually considered, an individual being. It has, indeed, a congeries of roots, a pith, a principal stem, and a general covering of bark, *in common;* serving the purposes of sustentation, support, and protection to the whole; but it has not only *one*—it is composed of *many* principles of life dispersed over its whole surface. A tree is a vegetable polypus; capable of unlimited division and subdivision of its parts, without injury to, and without any notable diminution of the original. Not only is every seed, but every bud a perfect being, endowed with a living reproductive principle in itself; and whilst a tree is considered as a vast assemblage of vital entities, requires to be treated as if only an individual.

As some of the foregoing ideas are new, and at variance with generally received opinions on the subject, the writer only craves a patient examination of his statements. He appeals to nature; and trusts that the impartial and unprejudiced inquirer after truth, by comparing the phenomena themselves with what has been advanced concerning them, the conclusions on both sides will not greatly differ.

In the preceding part of this section we have asserted, that all new accretions spring from a previously organised body; whether that be a propago or seed which is deciduous, or from any part of a plant, as a bud, graft, layer, or cutting (that contains a part of the vital membrane and incipient buds,)

separated by art. This idea is however controverted, it being held by many eminent physiologists, that the new accretions are formed out of the elaborated sap; and particularly the new layer of alburnum, which is every year added to the axis of the stem.

In whichever light we view the different appearance, state, or qualities of the sap of trees, &c., whether as gum, resin, jelly, or water, it is perfectly homogeneous; and whether contained in the body of the plant yielding it, or in the gallipots of the druggist, it is always found free from any fibrous or other matter that could possibly by combination form the organic structure of a plant. We are, therefore, we may again repeat, confirmed in opinion, that woody structure and substance can no more start into existence without a rudimental basis, than that an entire tree can be produced without either seed, cutting, or layer. Vegetable growth is only distension, expansion, or amplification of a rudimental membrane: and the elements composing this membrane are increased by the assimilating power of the organic apparatus of the plant.

Appendages of the stem.—These are hybernacula or bud covers, leaves, stipula, spines, prickles, tendrils, glands, awns, hair, downs, bractea, natural exudations of the juices, and floral members.

Hybernàcula.—As seeds have various coverings, so buds, whether of leaves or flowers of shrubs and trees, are protected during hybernation, or before expansion, by an envelope of membranaceous leafits

which are usually deciduous singly, or thrown off together like a cap. They are seated at the base of the bud, over which they are arranged like scales. In some plants the hybernacula are covered with down: others with a thick adhesive gum, which is an additional security against frost. The sheaths of the *Gràmineæ* and of bulbous and tuberous stemmed plants, are only modifications of this temporary defence. This appendage is particularly imposing in *Cròcus;* and on extra-tropical trees, every bud, whether prominent or incipient, is furnished with this kind of protection.

Leaves.—The leaves are the most striking appendages of plants. As they are beautifully organised they must answer some important purpose in vegetable economy. They have been called the lungs of the plant, no insignificant term; and as they aggregately present an extensive surface to all atmospheric influences, they must be, from this very circumstance, considered as indispensable members of the system.

That extended surface and foliaceous structure are necessary to vegetative development in general, may be inferred from the fact that the stems of many of what are called succulent plants, and which have few or no real leaves, are flattened so as to present as large a superficial plane to the air and light as possible.

Leaves are inspiratory as well as perspiratory organs. Gaseous qualities are probably emitted as well as inhaled by them; and that they both absorb and perspire away aqueous matter is well known.

Such functions are mainly instrumental in producing a constant flow of sap upwards. In proportion to the expanse, or quantity of foliage, in like proportion is the need and consumption of water. Indeed their hydraulic agency seems to be their chief office ; the amplification of the plant could not take place without such agency to assist the intestine impulse of the swelling vessels. It has been observed that shoots having leaves upon them, cut off from the tree, quickly wither ; but, if the leaves are taken off, the shoots will remain plump a much longer time ; a proof of their transpiring powers.

Although the leaves are attached to the bark before as well as after their expansion, the connexion is only temporary. Those of deciduous trees drop or wither as soon as the summer growth is over. Some shrubs and trees shed them in the second or third year, hence they are called evergreens ; and the fir tribes retain their foliage for many years. In the latter case it seems their persistency is only owing to the resinous consistency of the sap and suberous character of the bark, or rather that they are not all appended to buds as are those of other trees. In all cases the attachment is not very intimate ; there being no connecting fibres or other vessels of a permanent character passing from one to the other ; all such being articulated at the junction, except only the palms, in the early stage of their growth, and all other plants having what are called "spurious stems," viz. stems chiefly formed of the permanent bases of

the petioles. The sap vessels of the bark are continued into the leaves ; but their office as ducts ceases with the fall of the latter.

In structure leaves are furnished with a beautifully branched petiole, curiously divided and articulated like arteries and veins, or ranged in nearly parallel lines ; the interstices being filled up with a pulpy, parenchymous, green substance, covered on both sides by a cuticle, which is said to be porous to allow the transmission of fluids. That the superior and inferior surfaces have different functions, or are differently acted on by the air and light, is manifest from the circumstance, that if their natural position be reversed by force, they will very soon regain it if at liberty. There is a remarkable exception to this, however, exemplified in the genus *Alstrœmèria*, the leaves of which having tortuous petioles present their inferior disc to the sky.

Leaves differ much in substantiality ; some are thin and transparent, others thick and fleshy. Those of some of the *Alöes* and *Crassulàceæ*, as has been before observed, cannot with propriety be called leaves, because, if slipped off and placed in a favourable situation, they become perfect plants ; thus exhibiting a property of a stem rather than of simple leaves. Such appendages are in fact foliaceous stems. There are several plants whose leaves, if planted in moist heat, will exsert root fibres, and keep the leaves alive for a considerable time ; but being destitute of the organisation of a stem, never can produce any

additional member of a plant. Leaves there are, however, which have a peculiar organisation, as those of *Phyllànthus* and *Bryòphyllum*, (Figs. 48 and 49,)

Fig. 48.

Leaf of a *Phyllanthus*, showing the flowers borne on the edges.

Fig. 49.

Leaf of a *Bryophyllum*, bearing viviparous progeny.

the branched petioles of which are the peduncles of the flowers, or the runners for bearing the viviparous progeny of the plant. There are other bracteous leaves similarly organised, as *Echeveria livida*, which, if only laid on moist soil, readily strike root, and produce new plants. The leaves of *Gloxìnia* produce young plants. A callosity is first formed from

the bottom or broken part of the midrib; this increases to a kind of tuber which, after a time, ejects both radicles and stems, a clear proof that detachments of the vital membrane are projected into the leaves.

Leaves are, except in some of the *Coniferæ*, always closely connected with the buds: indeed, it seems the former are only detachments of the bark to permit the escape of the latter. They generally accompany each other; and in some kinds of trees the buds are formed within the base of the petiole.

Amplitude and deep colour of the foliage are sure signs of high health and vigour, as a pale colour and diminutive size of leaves are indications of weakness or disease. So the rugose texture of their surface is a mark of barren luxuriance, whilst compactness and polished appearance of the disc, indicate not only perfect health, but fruitfulness also. This is strikingly visible on the grape-vine, melon, and strawberry: the reason is, perhaps, that the swelling fruit requiring a large share of the rising sap, checks the expansion of the leaves, and renders them firmer in texture and less in size.

From the state or changes of the leaves it is quite evident, that though the root be the chief organ for supplying the nutriment of the plant, the leaves are certainly the exciters of what may be called the appetite. They are constantly, especially under the action of a cloudless sun, craving supplies. Their surfaces all turned sunward, receive both light and

heat, whence they derive colour, and their juices motion; the latter become subtilised and evaporable, and as they fly off, leave them insatiate for fresh supplies. This agency of the foliage, therefore, gives an impetus to every current in the system, and consequently must have a powerful effect in advancing the amplification of the plant.

To the agency of the leaves have been ascribed the fruitfulness of trees, and the more perfect maturation of the tubers of herbaceous plants. Both bulbs and tubers, it is said, being more or less enlarged according as the leaves are able to "throw down" ample supplies of elaborated sap. Now, although it be unquestionable that the leaves are recipients of divers atmospheric principles and influences necessary to the plant, and their amplitude and vigour are proof of their powers for that purpose; yet we find on examination, that the rule is not universally true, that bulbs and tubers are large in proportion to their system of foliage. We may only instance the most leafy individuals in a field of turnips, carrots, parsneps, &c., which are always found to have comparatively smaller tubers than the less leafy portion of the crop. We may also remark the disparity of the tubers and foliage of the short-top radish, as further proof that tubers are not always in size proportioned to their quantity of leaves. Moreover, we may repeat, that both bulbs and tubers are occasionally produced without the assistance of leaves.

Stipulæ.—This name is given by botanists to a

minor order of foliage usually seated at the base of the proper leàves, in the near neighbourhood of the buds, to which, perhaps, they are in some way necessary. Their special use in the system is not, however, very apparent, though from their station they may be necessary in some way or other to the maturation of the buds.

Spines, Prickles, Stings.—These are called the armature of plants. Spines originate in the wood, as *Py̆rus,* and seem to be abortive shoots. In *Ulex* they are the extremities of the branches, and retain their vitality for years. Prickles are produced on the bark, or on the leaves, and have only a temporary existence. Both these appendages are ostensibly for defence against browsing animals; more especially of those kinds of plants that are armed when young, but lose their armature when grown up and out of the reach of cattle: example, the whitethorn. Some trees appear to be particularly guarded against climbing animals, as *Gledìtschia hòrrida.* Many plants, as *Mammallària,* are leafless, but profusely covered with spines; these, probably, do the office of leaves; but other functions are attributed to them, namely, that they are conductors of electric currents sùpposed to be especially necessary to these plants. Stings, awns, hair, down, on the surface of plants, are all appendages of the same nature, and all necessary one way or other in the economy of the vegetable. The hairs on some twining stems are reflexed.

Tendrils.—Are tortuous processes produced by weak stemmed plants to enable them to cling to, and support themselves on other plants or bodies in the air. Some are produced from the wood, and are permanent, though they lose vitality in the second year, as the grape vine. In this last-named tree, the first two, three, or four tendrils at the bottom of the shoots, are the common peduncles of the thyrse of flowers if they receive the requisite supplies of air, light, and heat; but if these elements be wanting, the flowers are imperfect and abortive : of course the peduncle is resolved into a barren tendril. Every plant that is furnished with such members shows its climbing character, and that it is not intended by nature to grovel on the ground. Some climbers support themselves by the reflexed position, or twisting character of their petioles, and others by the paw-like form and insinuating processes of their clinging fibres. Spiral tendrils convolve first one way for about half their length, and afterwards the contrary way.

Glands.—Are small protuberances seated on various parts of plants. They appear to be either secretory or excretory organs. Root fibres are observed to proceed from them in the case of layers. Those on the petioles are particularly conspicuous, and from their form only, it has been conceived they indicate a peculiar character of hardihood, or a certain susceptibility of the plant to suffer under, or resist, certain influences of the atmosphere. On the

young luxuriant shoots of the vine, small transparent bodies like vesicles decorate the stem, petioles, and tendrils. They are slightly attached to the cuticle; but what their use may be in vegetable economy is not apparent. They are, however, evidently of a glandular character, and of the same nature as the icicle garniture of *Mesembryànthemum crystallìnum*, and of what is called *bloom* on many kinds of plants.

Exudations.—Besides the accidental flow of sap from wounds, there are several instances of natural discharges which may be noticed. The buds of most of the *Pìnus* genus are covered, during winter, by a coat of pure resin, which is exuded from the hybernacula. Those of the *Pòpulus balsamìfera* are shielded by a fragrant gum. Honey-dew has been considered as a discharge from the leaves and stem; but as this is never seen unaccompanied by the *Aphides*, it is probably emitted by those insects. The fluid oozing from the naked stigma is no less remarkable than is the real honey secreted in the bottom of the corolla. Both are elaborated and secreted by the flower, and, as well as being necessary as food for numerous insects, furnish for the use of man one of the purest and most luscious of vegetable extracts. A curious distillation of water is preserved by the *Limnōcharis Plumiēri*, which, from a tube occupying the middle rib of each leaf, discharges pure water in frequent drops from an orifice at the apex. Being an aquatic, it would appear that the plant is

furnished with these pipes to carry off any excess of water received into the system.

Bractea.—This is a foliar expansion, occupying a middle station and character between the proper leaves, and the floral members of the plant. Though most commonly seated below the florets, as in *Justìcia*, it is above them in *Eucomis*. In some instances it resembles the proper leaves, as in *Mèspilus;* but is often of a membranous texture, as *Hellebòrus*. In some cases it is not easy to distinguish bractea from involucre, or even from the calyx. The spatha, perhaps, is only a modification of bractea borne by liliaceous plants.

Were it necessary to proceed with each succeeding member of the inflorescence, we should have to notice in the order of their development, the calyx, corolla, nectarium, stamina, pistillum, pericarpium, or fruit; but these are all so well known and so minutely described in every botanical work, that the task would be superfluous, especially as it would elicit nothing new, or at least nothing but what has been already mentioned, or what will require to be repeated when we come to treat of the expedients necessary to be attended to, or practised, in cultivation. We have alluded to the functions of the different members of plants, as we have had occasion to mention them; but we pretend not to know the uses of all. In considering the floral members, we see the use of the bracte, and also that of the calyx; both being evidently defences to the sexual organs; and these last, from

their station and peculiar functions, declare at once their respective offices. But what can we say of the corolla and nectarium, those splendid appendages and chief ornaments of plants? Do they administer to the perfection of the interior parts? They can hardly be deemed defences, more especially as they are not only unfitted for such office, by reason of their extreme delicacy, but also because, in most cases, they turn away from the only position in which they might act as a guard to the interior parts. Here we can only pause and admire! But notwithstanding our ignorance in this case, we may rest assured, that these beautiful appendages are not superfluous, but answer some useful purpose to the plant itself, or to some other link in the chain of being. Do their colours indicate their specific qualities for the use of man? Are their brilliant hues intended to lure insects, in order that they may not only find food, but also assist nature in the distribution of pollen*? Or are high colours given to plants as a decoration only? Such questions have not yet been satisfactorily answered, though we may safely conclude, that both the distinguishing characteristics of colour and scent are produced by the qualities of the plant, notwithstanding the immediate causes of the various

* There are some sorts of improved fruits, which, if their seed be sowed, rarely produce progeny exactly like the parent, or like each other. Is not this owing to the flowers being so constantly visited by numerous tribes of bees? *Ex.* the gooseberry.

tints in the same flower, and specific scent of all flowers is beyond our comprehension. But as a general remark we may add here, that when we con template all these various members of a plant, whether with regard to their structure or functions, we see much to fix our attention ; the diversity of forms and of texture—the extreme delicacy and vivid colour of the flower—the rich pulp of the fruit—and curious conformation of the seed-vessels are all admirable ! and when we consider further, that all these forms, whether ligneous or succulent, are composed of simple cellular matter, we are astonished ; that the same element should be so differently arranged—that such different qualities should be concocted—such odours effused, and such colours reflected from the same material !

CAUSES OF THE BARRENNESS OF TREES EXPLAINED.

Having noticed the different members of trees in the order of their development, we now proceed to another branch of the subject, in order to advert to some circumstances of the growth which are involved in considerable obscurity.

In the foregoing remarks on vegetable structure it has been assumed, that every part of a plant has specific form and existence before expansion. That there is no such thing as accretion by addition of new organs, but simply by extension and amplification of those already in existence. But as there are several circumstances which appear to militate strongly against this idea, it is necessary some explanation should be given.

The opposing circumstances are the following, viz.—

If all trees of the same age and kind are formed alike, and every one composed of every member or part that ever will or possibly can be produced, how does it happen, that one shall be fruitful and another barren?

Why does a fine, healthy, free-growing tree show

no flowers, and consequently yield no fruit, while a stunted, or even a sickly one, yield both abundantly?

How is it that a tree, a grape vine for instance, in full vigour as to age, and previous fruitfulness, shall suddenly become barren if removed from a higher to a lower place in the vinery, though at the same time its growth be accelerated?

Why are healthy shoots from the stem, or from the crowded interior of a tree, always sterile, whilst those of the exterior are prolific?

Before these questions can be answered, or the answers understood, it will be necessary to consider first the real nature of the connection between those members which constitute the bulk of the plant and the fructiferous gems contained therein. The former are the annually increasing bodies of bark and wood; these are enlarged to a greater or lesser size, and in a longer or shorter time by the favouring circumstances of *soil*, *situation*, and *season*. The incipient fruit-bearing gems are seated on the pith at the base of every bud, whether lateral or terminal, of our common fruit-trees; but their development does not depend on those circumstances which prompt and assist the growth of the wood and bark, but on a *stationary repose* in which their organisation is engrossed, matured, and fitted for perfect and vigorous expansion, by the influences of full *air and light*. The maturation and development of the fructification are subdued by the exuberant growth of the other constituents, whereby that rest, or stationary existence is denied, and there-

fore the gems are either carried along another stage in the growth of the shoot or spur containing them, or remain inert in the body of the stem for ever.

But why, it may be asked, if the fructification be centrally posited as in the bud *g*, Fig. 47, and ultimately displayed on the summit of a similar one on a spur as at *f*, Fig. 47, how is it not protruded, as it is natural to suppose it would be, at the first movement of the bursting bud? To this it may be replied, because the incipient flower is then imperfect, i. e. imperfect as to bulk, not as to form, and because, at the same time, such is the excitement of the growing principle, that the bases of the buds *h*, *h*, Fig. 47, enveloping the fructification, are elongated forth, carrying the gem forward therewith in their apices. We are now alluding to leading shoots, which are seldom fruit-bearers; but that fructiferous gems are present in the points of even strong leading shoots, we have only to recollect how often we have seen terminal flower buds formed in the autumn on both apple and pear trees as at *c*, Fig. 47. It appears, therefore, that though the fructiferous gems are incipiently present in all cases, it is absolutely necessary to their perfect maturation in the bud, that moderate growth of the tree to allow time for this, and full supplies of air and light are requisite to bring them to perfection.

There can be no doubt but that the flower bud *c*, Fig. 47, was at the base of the shoot, or in the bud whence it sprung, before its elongation in the previous spring;

and that the flower bud *f*, was only a leaf bud twelve months before. But here it may be asked how does this terminal bud *c*, Fig. 47, gain maturity without that stationary repose which is affirmed to be necessary in other cases? Because such shoots bearing flower buds cease to grow at an early period in the summer, as every one acquainted with fruit-trees must have observed, and this topmost bud, from its central station, thereby receiving extraordinary excitement, is forced into perfect form in advance of those which are laterally situated on the same shoot.

But the fructiferous organs are not always terminal. In many plants they are projected laterally, and are perfected in the first, second, or third year, according as circumstances are more or less favourable. The peach and Morello cherry are perfect in the second year; those of the May-duke cherry, naturally, not till the third; but as a proof that flowers are present in the lateral buds, even in the first, we may instance the practice of Mr. Fintelmann, royal gardener at Berlin. This respectable practitioner finds that if he stops the strongest shoots (of his potted May-duke cherries intended for forcing) in the month of June, or some time before the summer growth is over, and divests the lower part of the shoot of two-thirds of its buds, those that are left will put forth flowers and bear fruit the following spring.

Thus, then, it appears, that, though the fructiferous organs are incipiently present in all cases, they either require a certain maturation (technically,

ripening of the wood) in a stationary state, or some preternatural excitement before they can be perfectly developed. Thus it is why luxuriant growing trees are barren; and this is the cause why a tree deprived of full air and light yields no fruit; and also the cause why a branch of a fruitful vine, if lowered from its station near the glass down on a trellis near the floor, will grow luxuriantly, but instead of perfect branches yields only naked tendrils.

The fact, that over free growth retards the production of flowers and fruit is evident from many circumstances occurring in vegetation. Seeds, from long keeping, or from being immoderately dried, always rise with less vigour, and present the fructification sooner than such as are fresh and plump. The reason is because the cotyledons are deprived of a part of their juice, which is destined to invigorate the infant plant; consequently, when sowed, they vegetate slowly and imperfectly; but the corculum, from its central position, being less debilitated than its investments, progresses before these, and the result is earlier flowering and maturity of fruit.

If bulbs be exposed to unnatural desiccation, the outer investment becomes parched and stationary; but from the central store of sap and vitality the flower issues forth before the leaves. Or, in the case of a bulb being injured by frost, the leaves only are paralysed, and the flower stem is protruded alone.

That the fructification exists, and has form as soon as the other parts of the plant, is manifest from

the history of the *Anàna*. T. A. Knight, Esq., in one of his papers presented to the Horticultural Society, asserts, that the effects of very dry or very cold air will "*cause even the scions from their roots to rise from the soil with an embryo pine apple upon the head of each, and every plant to show fruit in a very short time, whatever were its state or age.*" Now this shows decidedly that the whole organisation of the plant is complete from the first, and, by checking the growth of the exterior, the central part, bearing the fruit, comes forth prematurely; but which could not be the case did the formation of the fruit depend entirely on the quantity of sap "thrown down" by the leaves.

Annual plants run to seed sooner or later according as the soil they grow in is rich or poor. On a dry gravelly soil plants are diminutive and precocious; on rich fertile land they are exuberant and late: because the growth of the stem and leaves, deriving a full supply of nutriment, are enlarged to their utmost volume, and of course delay the development of the flowers and seed. Here it may be added, that the difference in the magnitude of plants of the same kind is not so much caused by a diminution of the number of their parts, but by the diminished bulk of each of them.

From the whole of the foregoing observations it is sufficiently manifest that every different part of a plant has original existence. From the moment it begins its career of growth all its parts are in a course

of gradual development; sometimes, in the case of trees, the two principles of growth and fruitfulness progress together, equally balancing each other; at other times controlling or neutralising each other; abundant fertility checking the growth, and exuberant growth preventing fruitfulness.

Here it is necessary to observe, that trees may be barren from other causes than over-luxuriant growth. The fructiferous gems or principles may be present though abortive; trees may be covered with flowers, and yet produce no fruit. This arises either from constitutional weakness, the depredations of insects, or ungenial weather. A vine may show its incipient bunches at every bud that bursts; but if there be a want of air, or light, or heat, or of sufficient energy in the tree, no flowers will be expanded, nor fruit perfected; the bunches will be resolved into tendrils.

When the growth of a tree is moderate, and when flower buds are exhibited over all the spray, not only are the flowers of this year strongly formed and expanded, but those of the next are ready to start forth; and, it not unfrequently happens, do come forth late in the summer or autumn, especially if the first flowers have been cut off by frost, insects, or other accident. It is in such cases we sometimes witness a struggle between the growing and fructiferous principles; some of the second flowers become monstrous; the axis of the shoot being prolonged through and beyond the imperfect flower, leaving a portion of the pulpy part of the pericarpium on the

shoot, at the point where a perfect fruit, in other circumstances, would have been formed.

Notwithstanding this irregularity, and intermixture of distinct organs in the growth, (which may be easily traced to be effects of accident, or extreme cultivation,) it has furnished some physiologists with an idea that such exhibitions indicate the true reason why one tree is prolific and another barren : why one tree shall every year be covered with blossoms, and another of the same kind present nothing but leaves. The sexual organs of plants they assume have no *positive identity;* but are only modifications of the previously existing members which compose the stem, and which are resolvable, either into leaf or flower-buds, as circumstances govern.

That there is some corresponding analogy between the members of a stem and those of a flower, may be admitted. We have only to refer to the doctrine of the old botanists for confirmation. They declared that the calyx was the termination of the outer bark —the corolla, that of the liber—the stamens rose from the wood—and the pistillum, &c., from the pith. These old ideas have, however, become obsolete; and instead of them we are now taught, that " the pistillum is either the modification of a single leaf, or of one or more whorls of modified leaves," and " that in the course of the advance of it to maturity, many alterations take place in consequence of abortion, non-development, obliteration, and union of parts."—*De Cand.*

This doctrine being espoused by some of the most distinguished botanists of the age, it is painful to be compelled to doubt the accuracy of such authorities. Perhaps it is necessary to dip deeply into the abstract science of physiology, before we can comprehend the arcana of vegetable transformations. Mere practical discernment cannot exercise such powers of imagination as to conceive, that by checking the free growth of a tree, it will induce an accumulation of matured sap, which shall operate so as to stunt the points of the branches into flowers—turn the most simple appendages of the exterior into the interior—and transform these inferior organs into the principal and most important of the system. Can any practical man imagine, that by checking the growth by transplantation—cutting the roots—ringing or disbarking a tree, that such violence will gain a greater share of matured sap?—impossible. On the contrary, he knows the effects will be injurious to the whole system; and though the fructiferous principles will be called into action as the final effort of a sickly tree, this result is not from an accumulation of sap, but the very reverse. Surely accidental metamorphoses may be acknowledged as such without overturning the natural order of vegetable development.

Whether the old or the new ideas on this important point of vegetable physiology, be the more correct, or whether the one or the other be faithful descriptions of the origin and conformation of flowers,

we shall not presume to decide; but venture to assert that if the modern notion be true, it detracts from the ideas generally entertained of the simplicity and beautiful arrangements of vegetable structure and evolution, and which we naturally deem to be *results of fixed laws:* whereas, it seems that such essential forms are only the effects of adventitious associations!

If, however, proofs of these fortuitous conformations were afforded by plants in a state of *uncultivated nature*, some credence might be bestowed; but when they are only drawn from pampered varieties, *the monstrous children of art*, in the shape of roses, Crasanne, or Colmar pears, highly cultivated plants, we deem the examples unsatisfactory, and inferences from them erroneous.

Irregularities, malformations, abortions, and monstrosities, are frequent among highly cultivated plants. The chief favourites in the flower and kitchen gardens are examples; but they are all casual, and confessedly *spurious* productions: being exceptions to the fixed laws of vegetable development, and in no case to be taken as a rule in describing it. Irregularities in development are also seen independent of any interference of art. The round and imbricated galls on the oak, and the mossy tufts on the shoots of the sweet-briar, are the niduses of insects. But these, like the manipulations of man, only cause aberrations in disposition, and multiplication of parts, without being considered as constitutional characteristics. We

sometimes see the mutilated scape of a narcissus resolve itself into and do the office of a leaf, but it would be truly wonderful to see a leaf, or any number of leaves, resolve themselves into a flower! We also witness the mutability of monœcious and diœcious flowers; showing that such plants are constitutionally provided with the principles of both male and female flowers on other parts of the plant than where they usually appear: and that soil, situation, or season sometimes operate to produce either or both, as circumstances determine. Even the mutilated stem of the common white lily will produce bulbs at the fracture, when the development of the flower is prevented. But to maintain that the flowers have no positive identity in the constitution of the plant, or, what is nearly the same thing, formed of the proper leaves, is and must be as perplexing to the botanical student as it is to the practical man. The latter is well acquainted with the transformations visible among highly cultivated plants. He ascribes them to accident, and to the changeability of the vegetable fabric under the expedients of cultivation. And though he may wish to believe, that by possibility a flower is but a stunted branch, for the sake of agreeing with his superiors in science; yet he finds much difficulty in applying the doctrine generally. Among pomaceous plants, a distant resemblance may be, by the help of imagination, traced; but how can he apply the doctrine to such plants as the tulip? in this case he must call the flower an

expanded offset: in *Stapélia* and *Céreus*, where there are no foliar expansions, the flowers must be considered as distorted stems: in *Mammalària*, *metamorphosed mammæ*, and the flowers of such plants as the strawberry, must be accounted floriferous runners. If flowers of trees be stunted branches then perfect branches are runaway flowers; and if sepals, petals, filaments, and pericarps be only modified, contorted, and discoloured leaves, then are perfect leaves only vagrant bracti, sepals, &c. &c.

Much satisfaction and amusement, no doubt, arises from the study of the more occult processes of vegetable transformations; and there is much merit even in the attempt to give a rational account of them; but much care is necessary to distinguish perfect from imperfect, regular from irregular development. When perfect, the arrangement of structure, the form and functions of the several organs, and all the exhibited phenomena of growth, are similar in every plant of the same family; but occasionally individuals differ, and fly away from the regular order of development. Some accident of treatment, perhaps, or peculiar circumstance arising from soil, situation, or season, will cause derangement of structure by reduplication of members, as in double flowers, or by partial destruction or mutilation of organs. Some genera have constitutional powers of metamorphoses, yielding plants, instead of seed, as *Lílium;* compressed, instead of quadrangular or cylindrical stems, as *Aspàragus, Epiphýllum*, &c. These last are

constitutional deviations; the former are only, as before observed, accidental exceptions.

In fine, science has proved, and experience confirms the fact, that the floral members are resolvable into leaves; but the difficulty with the practical man is, whether leaves be resolvable into flowers and fruit.

That curious and at the same time elegant ramification of pedicled glands on the cuticle of the common Provence rose, hence called moss-rose, is said to be only an accidental variation, caused originally by the kind being planted in a very damp and shady situation: and it is affirmed any rose may be made mossy by keeping it constantly in the shade, and where the air is peculiarly moist from want of ventilation.

APPLICATION OF PHYSIOLOGICAL KNOWLEDGE TO THE VARIOUS PRACTICES OF THE CULTIVATOR.

SECTION I.

Sowing.—The components of a seed have been already noticed and described as consisting of the embryo plant, contained in one, or between two or more cotyledons, which are the kernel or farinaceous lobes destined to support the infant plant while it is establishing itself in the ground. These internal parts are protected, after separation from the parent, by two, often three investments, in the form of membraneous films, coriaceous coats, or hard woody shells.

Although nature, in many instances, has made provision for the dispersion of seeds by furnishing them with volant appendages, or ejecting them from elastic capsules by which they are scattered to considerable distances around, yet there is no provision for covering them, except the fallen leaves, the treading of cattle, or other accidents. They are shed where they grow; and the season for ripening is also the natural season for sowing. This holds good with respect to every plant existing in its native habitat, as we find in the case of weeds; but among the mul-

titude of cultivated plants a great majority are exotics, requiring various and even unnatural seasons for committing them to the ground; as well as to allow time for the necessary preparation of the land, as for the seasonable uses of the crop.

The vitality of seeds is more or less persistent according to the qualities contained in the body, or in the coverings. Some require to be sown soon after they are ripe; others retain their vitality for many years, if protected from the changes and influence of air; but it is to be observed, that the longer they are kept in the granary or warehouse, the less vigorous do they rise from the seed-bed.

The most vigorous plants rise from the most perfect seeds. In all cases where mere bulk of wood, stem, foliage, or of flowers, is the object, the newest, ripest, and plumpest seeds should be preferred; but if early flowers or fruit should be desired, older or artificially dried seed will best answer the end.

Many are of opinion that provided the corculum of the seed be entire and uninjured, it signifies little how diminutive the cotyledons or quantity of albumen may be: for as soon as the embryo is fairly born, say they, it is instantly independent of the cotyledons. This is only partly true; because a seedling, deprived of its cotyledons before it has expanded perfect leaves, is always seen to suffer from the loss of them. It must be admitted, however, that the siftings of peas, and thin berried turnip-land wheat, are both used for seed without any visible disadvantage.

Full air, a moderate degree of moisture, and a temperature suitable to the kind of seed, are all necessary to perfect germination. The heat of the soil at seed time, whether in spring or autumn, is generally between 40° and 50° of Fahrenheit; and this is sufficient for corn and all other plants suited to the British climate.

By dissection and close inspection of the germination of seed, a pretty clear idea may be formed of the process. A certain degree of humidity softens the husk or shell: the constituents of air and water are absorbed by the cotyledons, and with the excitement of a necessary degree of heat the whole swells; the rostell protrudes through the integuments, and proceeds or turns downward into the earth; and soon after the infant stem rises into the air. The seed is matured by the parent by means of an umbilical attachment or cord; but whether the new radicles are an elongation of, or proceed from, this cord, the writer has never been able to ascertain.

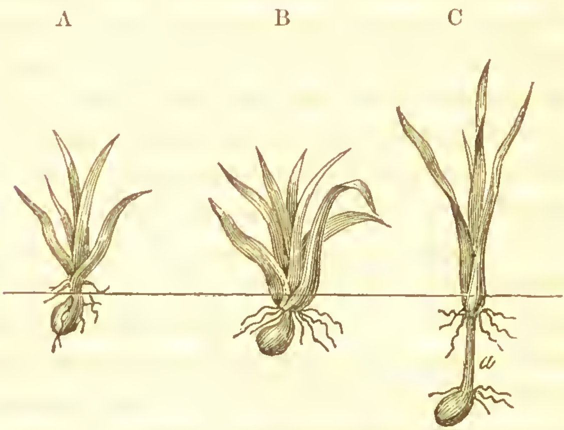
The size of seeds determines the degree of comminution to which the surface soil should be reduced to receive them; and also the depth at which they should be laid in. Large seeds, as those of the Spanish chestnut, require to be embedded at the depth of one and a half, or two inches; whilst acorns, mast, and other such sized seeds and corn, require a covering of about one. This is a matter of more importance, and requires a greater degree of care in the performance than is commonly bestowed on it, especially in agri-

culture; because nature plainly shows us, that if seeds be either too much exposed to the air, or too deeply buried in the earth, their development must be imperfect.

As the proper depth at which corn should be sown is of the utmost consequence to the farmer and to the nation at large, the manner of the development of corn seeds may be here portrayed, in order that the cultivator may be convinced that a proper depth is highly necessary to the success of the crop.

The structure of graminous plants has been already described; here we have to show the difference in the development of a seed laid in at different depths.

Fig. 50.



The figure A represents the growth from a seed which happened to be laid not deep enough in the soil, and consequently not having a sufficient hold

thereof, becomes liable to be blown down by the wind before the ears are perfect.

Figure B shows the development of a grain of wheat deposited at the proper depth. In this we see both the fibres and first stem issue from the same end of the grain; the first spreading themselves around, and the latter rising directly and vigorously into the air.

The sketch at C is that of a seed buried two or three inches deep. In this the first fibres are ejected as in the last; but, being too far from the air, the first internode of the ascending culm is unnaturally elongated; and at the proper depth the second joint ejects the roots, which, with others produced from the joints above, perfect the plant. As soon as the secondary set of roots is formed, the first, being no longer useful, immediately perishes. Here we may observe that, though nature accomplishes her purpose of forming roots at the due depth from the surface, yet it is at the expense of an unnecessary waste of power: and moreover producing a delicate member peculiarly liable to be the prey of insects and slugs in the soil before the crown roots are formed.

It is this circumstance which so plainly points out the due depth at which wheat and other cereals should be deposited: and furnishes a good practical lesson to the farmer, never to sow *before the harrows:* or if he drills, never to allow the shares to go deeper than one inch into the ground; or at least to see that the seed be not covered more than one inch.

There is another circumstance in respect of wheat

which shows the necessity and advantage of shallow sowing: it is this—wheat is sowed, and sometimes late, in the autumn; if immediately after the plough, much of the seed falls too deeply and closely together between the furrows. The seminal roots are, of course, first put forth, the points of the first leaves appear above ground; but the winter sets in, before the coronal roots are produced, and consequently the plant is only sustained by the first roots, and through that slender stem, *a*, Fig. 50 C, amid all the changes and rigours of a winter's frost and snow. The coronal roots do not appear before the end of February or beginning of March, (the proper time for top-dressing wheat,) and all the time previous to this taking place, and during the severe season, the plant is in jeopardy as well from alternate frost and thaw, as from wire-worm, slugs, and insects in the soil. But in the case of sowing at the proper depth, the seminal roots are in their proper place, and are there much stronger; and granting that the secondary roots are not put forth till the spring, the plant has not that slender canal exposed to the attacks before alluded to.

With respect to the proper depth for smaller seeds, if they be but just covered so as they receive at the same time a moderate share of the moisture always more or less present in mellow soils, it is enough; one tine of the harrows in the field, and the smoothing action of the rake in the garden are all that are necessary for the generality of small seeds. Some very diminutive seeds only require to be pressed into the surface;

and which, if kept damp and shaded from the mid-day sun, will succeed better than if covered ever so carefully.

Almost all seeds require a well consolidated bed after being well ploughed or digged, wheat and pulse particularly; and this for two reasons: first because the seeds are equally affected by the close contact of the medium in which they are laid, germinate more regularly, and take a firmer hold of the soil; and secondly, because seed-weeds are less likely to rise in a compact surface, than in one which is loose, nor can slugs or grubs work their way so well in a close surface. Hence the use of rollers, pressers, and treading loose ground with sheep among farmers, and the practice of treading in seed by the gardener. These are rules both in agriculture and horticulture; at the same time, cultivators are aware that a fine, light, and dry soil is particularly favourable to the germination of some small seeds, more especially those of charlock (*Sinàpis arvénsis*) and common poppy (*Papàver rhæ̀as*).

Seeds in general are cast naked from capsules and glumes. The baccifera, pomifera, and drupiferous kinds undergo a preparation amidst the decaying pulpy coat with which they are surrounded. Those of the *Coníferæ* do not escape from the woody strobile, till the scales enclosing them are opened by the summer sun of the next year after they are ripe; and if the cones are gathered, as they should be, before the seeds are shed, it requires some labour to split, kiln-dry,

and thresh them, to discharge the seeds and prepare them for the seed-bed.

A few seeds receive a preparation before sowing: and many, especially such as have been long in the warehouse, would, no doubt, be the better for it. The excitement from a dry soil is not always sufficient to awaken the vital principle. It is said, that some seeds will not vegetate at all without the extraordinary stimulus of passing through the stomach and intestines of an animal! Be this as it may, we are well assured, that in the case of pulse seeds, their germination is accelerated by being steeped in water for a few hours before sowing. Soaking the seeds for an hour or two in oxalic acid, or slightly watering them with it after being sown, is said to assist germination materially.

Wheat is always prepared for sowing. This old custom is differently regarded by agriculturists as to its real object and efficiency. We hear nothing of brining and liming in old Tusser's time, 1575. Drawing the wheat seed, *i. e.* laying it on a table and separating the good grains from the bad, or *vice versâ*, was then the usual practice. This was the farmer's and his family's task on evenings during seed-time, a most tedious process; and no doubt gave rise to the custom of washing it, to separate at once the light from the heaviest grain. A lixivium made by the addition of common salt to the water was found best for this purpose of floating the light grains, smut-balls seeds, of weeds, and other extraneous

bodies, all which could be easily skimmed off. The wheat seed being thus quickly cleansed, was immediately dried by sifting quicklime over it when laid on the floor, which got it soon in order for the sower. This is now an established custom; and persevered in under the idea, that it prevents the disease called smut, though it has not been discovered in what way it acts as a preventive. Certain it is, however, the coating of salt and caustic lime does no injury to the seed, and may act as a defence to it against the attacks of birds and ground insects.

Much of the success of planting depends on the choice of the seeds from which young trees are raised, whether species or varieties. The properties which are transferable from the parent tree to its progeny are various, viz., resemblance in form and colour of foliage, flowers, and fruit; stature and mode of growth; in peculiar texture of the wood, as to ponderosity, tenacity, and durability. Amongst cultivated varieties of edible fruit-trees, all the above properties are transferable by seeds, except the increased size and improved qualities of the coverings of the capsules and shells, and the robust habit of the shoots and leaves. The qualities of kernels used in the dessert, are generally transferable by sowing. When, therefore, any of the first-mentioned properties of trees are required, seeds will convey them, especially if the seeds be taken from young vigorous trees, which exhibit the desired property most conspicuously.

Looking at the natural forests of Scotch pine, or of

the common oak, we can see considerable diversity of habit and individual character. Some are conical and aspiring; others are stag-headed and spreading. Such characters are conveyed by their seeds: hence it becomes the duty of the nurseryman, and the interest of every planter, to be careful in the selection of seed, whether intended for sale or sowing. There are certainly, for instance, two very distinct kinds of Scotch pine, one, of course, being a variety. The most common is of an upright and formal outline when young, and having a thick suberous persisting bark; the second has a smoother bark in consequence of the outer layers being thrown off piecemeal during the growth; it is also more irregular in form, and often presents an outline highly picturesque. One drawback against this last sort is, its liability to be shattered by the weight of snow lodging on the extended horizontal branches. The seeds of both sorts are gathered together, and it is not till the plants, raised from the mixture, are twenty years old, that their peculiar characters appear. So of the oak, *Quèrcus ròbur*, there are two varieties (*Q. sessiliflòra*, and *Q. pedunculàta*,) in our woods; the seeds of both are too often mixed and raised together, although the last is said to be a superior tree, producing the most valuable timber.

These circumstances are mentioned to show the necessity of pure seed being chosen from the best specimens of the desired sorts, for the reasons above given.

It may be imagined, perhaps, that as a seed con-

tains a young plant, it will be free from the constitutional defects as well as the decrepitude of the parent; but this we know is no less the case among vegetables than it is among animals. Defects frequently, and diseases almost always, are hereditary in both plants and animals. From an acorn of an aged oak a fine healthy tree may be raised, and which may arrive at even a greater magnitude than its parent; but if the latter had any peculiar manner of growth, either good or bad, the former will surely inherit it.

Although this be a general rule, it is not without exceptions. That variety of the *Fraxìnus excèlsior*, called *Pèndula* from the position of its branches, when worked and trained as an ornamental tree, is an accidental malformation of the growth, but which is not transferable by seeds; for they, when sown, go back to the original.

Almost all our culinary vegetables are varieties. Some are cultivated for the number, size, or close and early concentration of their leaves or flowers. Such are lettuce, cabbage, with its numerous varieties, broccoli, cauliflower, &c., and all salad herbs. The best, or rather truest of the sorts, are perpetuated by their seed, care being taken that on saving it none of their near alliances are in flower at the same time near them. Were this precaution not taken, the different sorts of the genus would be adulterated with each other; and the present highly prized sorts would be finally lost.

There is something unaccountable in comparing the fact of varieties and sub-varieties of herbs keeping

true to the variations of the growth produced by art and high cultivation, and the very different results which take place in improved fruit-trees, which cannot be reproduced by their seed. But in the latter case it must be observed, that the amelioration of the wild crab to that of the golden pippin apple, for instance, is not a change of the real fruit, that is, the seed, but an enlarged addition to, and an improved quality of, the pulpy covering of the pericarpium*. The same is the case of the pear, orange, &c.; it is not the seeds that are altered by cultivation, but the character of their investments only. So that it appears by pampering the growth by high cultivation to produce larger shoots, leaves, and flowers, we also enlarge the integuments of the seed. The seeds themselves undergo but little change, especially in the cherry, apple, and pear; though more in the peach, gooseberry, and some others. But if we cannot reproduce our improved fruits by their seeds, except by accident, we may obtain improved varieties from the same by impregnation; the means of doing which will be noticed hereafter.

Some orchardists are of opinion that the amelioration of fruit is only occasionally produced from impregnated seeds, and that the generality of our improved varieties have gained perfection gradually and in course of time, without other treatment than is commonly bestowed on orchard or garden ground. It is likely that the first fruit from a strong seedling

* Seed vessel.

may be more crude and colourless than when full crops have moderated the growth, and qualified the exuberant pulp; but, as a general law, that fruit is improved by the age of the tree, we must take leave to deny. It may be remarked, however, that in the United States of America, old established orchards are said to yield fruits of superior quality, to those from lately planted orchards of the same kind of fruit.

But that the seed of varieties of fruit-trees receive impressions from the pollen of each other, has been proved again and again, both by art and accident. By this means new sub-varieties have been obtained; but it appears that the artificial impression extends only to the impregnated seeds, and not to their progeny. The seeds of Knight's Early Black Cherry, though originally obtained by cross-impregnation, produce, when sown, the common wild cherry, like all the rest of the same family. In this it is like almost all our other varieties and sub-varieties of cultivated fruit.

Foreign seeds of curious trees, shrubs, or other plants, either tropical, or from very distant countries, are always found more or less damaged during the voyage. Some of them require soaking in water for a few hours before sowing, and all need a brisk hot-bed heat to prompt and assist vegetation. Nuts or hard-shelled seeds are sometimes assisted by having the points or bases of their shells filed off before

sowing. The spring of the year is the best time for raising exotics; because they then have our summer to encourage and establish their growth.

A properly chosen and well-prepared seed-bed is indispensably necessary for every kind of seed; it should always be rich, as well as of a suitable temperament for their reception. The stronger a seedling rises, the better able is it to withstand the vicissitudes of the weather. Many garden plants are raised in seed-beds, and from thence transplanted to where they are to stand for good. Some, like corn, are sown where they are intended to remain; either in drills or broadcast.

In both field and garden culture, drilling is certainly the best, as well as the neatest mode; provided always that the seedlings be duly and timeously regulated in their inter-distances, according to the spaces respectively required. By such means all crowding is avoided, and every facility given for the operations of the hand or horse-hoe. Ridge-drilling—that is, throwing two furrows together with the plough after the manure is spread, the seed being afterwards drilled along between—is suitable for turnips, beet, &c.; because the seeds are deposited not only in a mound of friable soil, but also in immediate contact with an accumulated portion of the manure, both favourable to the strong and quick growth of the seedlings. So necessary is it that every plant should enjoy its natural required space, that dibbing both wheat and

beans is found a profitable practice. By this mode the seeds are more regularly disposed—none are buried—and a considerable quantity saved.

Broadcasting, notwithstanding the very exact manner in which it can be performed by expert seedsmen, is liable to irregularity; not only from wind which may prevail, but from the inequality of the surface of arable land. Every hollow, and the furrows between the lands or ridges, always receiving more than their share of seed; if not from the sower's hand, certainly from the action of the harrows. Unequal distribution occasions unequal growth, and consequently an unequal sample of grain. Seeds generally, and corn particularly, should neither be sowed too thick or too thin. If the former, every part of the plant is drawn and diminutive; if the latter, on rich land, the corn becomes over-luxuriant—liable to be laid—more subject to blight—and though the grain may be larger, it is always inferior in quality.

Woods are sometimes raised from seeds. This is practicable; but the success depends entirely on the necessary preparation being complete, *i. e.* perfect cleanness of the land so to be occupied. No weeds should have a previous hold of the soil, otherwise they will materially check, if not even destroy, the seedling plantation. Subsequent care and attention must be bestowed to prune and encourage the superiors—draw out supernumeraries—and remove all worthless encumbrances.

A frequent change of seed is a necessary expedient in cultivation, in order to ensure the best returns. It is not only a change from one description of soil to another, but a change from one country to another. Whatever may be the cause that foreign seeds and plants do better than home-bred is not easily guessed at; but, taken as a naked fact, it is incontestable. A change of air and soil to a plant, seems to impart a new vigour, which it would not show in its native place.

As a general rule in sowing, it may be observed in conclusion, when mere bulk and full form of the plant, whether tree or herb, is desired, sow thinly, and keep in open order; when number, and superior quality of grain is the object, sow with a more liberal hand.

Seed-time.—It has already been observed, that the season of ripening is the natural time for sowing seed; but this is seldom necessary to be attended to, except in the case of a few curious plants. Our seasons, and the purpose for which plants are cultivated, regulate the time or times of sowing. Of some plants we only require the seminal, of others the perfect leaves. Young tubers, unripe pods, seeds, fruit, and flowers of many, and the perfectly mature seeds of others, are obtained by timeous sowing, and at periods fixed by the practical knowledge of cultivators.

SECTION II.

Transplanting.—Almost all our cultivated plants being raised from seed, or by other modes of propagation in seed-beds or nurseries, are from thence removed to their final stations by transplantation. The best time for this work is when the plant is at rest, viz. from the time the growth ceases in autumn, till its recommencement in the spring. An old proverb says—

> "He that would a good tree have
> Should bury the old leaves in the grave."

meaning that the fall of the leaves being a sign that the plant has entered on its winter rest, is the best season for removing it. This is spoken of deciduous trees; but it is unquestionably the best season also for the transplanting of evergreens; not only because the summer growth has ceased, but also because there is less sunshine, and less danger of the fibrous roots being damaged by drying air during the removal.

Success in all cases depends on the preservation of the young fibres, expedition in the removal, and seeing that the soil of the new site is sufficiently moist to encourage the re-striking of the young roots.

The younger a plant is, the easier and more safely is it transplanted; merely because it has but a slight hold of the ground, requiring no violence in taking up, and being extremely vigorous, readily lays hold of its new place. Herbaceous plants, whether young or

old, may be transplanted at any time, without risk of any thing, except perhaps their flowers, though it is best done when the plant is at rest.

The great advantage of transplanting trees in early autumn is, that though the leaves are fallen, and the visible growth stagnant, still it is observed that the roots are not entirely asleep; new fibres are exserted from new planted trees, even in November: these assist to establish the plant in its new place, defend it in some measure from the storms of winter, and prepare it to start with greater vigour on the return of spring. Both fruit and forest trees, may, however, be transplanted any time during the winter months when the weather is mild and open; but no planting should be attempted while the air is frosty.

From the description already given of the formation of roots it will be quite obvious that the delicate extremities or fibres are most liable to suffer on being removed from the soil. To save them entire requires all possible care; because the less damage they sustain, the less will the plant feel its removal. But as it is impossible to transplant a tree of any size so carefully but that some of the roots will be bruised or broken, and the whole receive a check, it is the planter's duty to give a little pruning both to root and head.

The branched head of a tree and its system of roots are "correlative parts;" they mutually depend on each other; simultaneously progressing or stationary. The circumstance of being equally balanced, as to

their respective powers, constitutes the health of the plant. If the roots be diminished by any violence, the head must lose a part of its supply of nourishment; and from the want of this it becomes and remains languid until the roots recover and resume their usual functions. If, therefore, any of the principal roots are broken in taking up, the stumps should be smoothly pruned off, to ensure the ejection of new fibres therefrom: a result which invariably takes place if the plant be healthy and favourably situated. But whether the roots be broken or not, all the working outlets are more or less damaged, and consequently incompetent to give their wonted assistance. In this case the practice is to reduce the head by pruning, so that no more should be required of the roots than they are able to afford.

Practitioners differ in opinion as to whether this pruning of the head be right or wrong; and also about whether it be best done in the first or second year after planting. Those who attribute all accretion to the agency of the leaves, deem it extremely erroneous to deprive a plant of any part of the foliage: and therefore insist, that to cut off the shoot that would be soon covered with leaves, at the moment too, when the languid roots need the utmost excitement would be, they think, actual murder! On the other hand admitting, as we must do, that the expansion of leaves invites the ascent of the sap, and thereby calls on the roots, as it were, to render instant

supplies; yet if this demand be made when the roots are in no condition to meet it, the consequence is a very feeble expansion of both leaves and shoots, evincing a general debility of the whole system. Those, therefore, who believe that these are the circumstances of a newly transplanted tree, advise the pruning down the last year's shoots that were produced by fibres now torn and useless, and which will not only lessen a demand that cannot be answered, but ensure the production of a new set of organs, viz. new roots and shoots, to come into play, and which will assuredly progress together with greater vigour.

Those who hold the opinion, that depriving a tree of any portion of its foliage is an injury, and that therefore cutting it in the second year is preferable to pruning it in the first, appear to argue inconsistently: because if pruning be detrimental in the first year, so must it also be in the second. Still we know many excellent practitioners in the market gardens about London (and none do better than they) in managing their newly transplanted standard fruit trees, defer pruning down until the second year; and even not then unless the weakly state of the tree renders pruning necessary. And their reasons are these:— a tree whose root has been established for twelve months, shoots with greater vigour after pruning, than a newly planted one: and should the trees take well to their new stations, which they seldom fail to do in such rich and highly cultivated ground, pruning

is unnecessary, because it would certainly delay the period of their bearing, a circumstance not at all desirable to a market gardener.

This horror of cutting off leaf-bearing branches is an interdict against all pruning. The doctrine may be regarded by the forester; but what is the orchardist to do when he wishes to renovate his old trees? His readiest expedient is decapitation, in order to obtain a new and extended head, either by regrafting or not.

But what are the practical facts showing that the above ideas of the state of a transplanted tree, and the propriety of pruning it as soon as transplanted, are correct? Several, we think, may be adduced. A cutting may be aptly compared to a newly transplanted tree; both are destitute of active fibres; in fact, both have these necessary organs to form before either can make any progress in growth. In this respect they are like a seed, which, in its development, first ejects its rostel into the ground. Would it assist the rooting of the cutting of any shrub or tree were the whole length of a shoot taken instead of a part? and would the same cutting or shoot of a deciduous tree have been more readily rooted while it was furnished with leaves, than after they had fallen? To both these questions, in respect to deciduous trees, the practical man will probably answer in the negative. Besides, with respect to the transplanted tree, but little assistance being derivable from the enfeebled roots, is it not better to concentrate this limited supply, and direct it to the production of a few new

shoots than allow it to be diffused and neutralised over the debilitated shoots of the former year? Let us observe what new vigour is imparted to a bud, graft, or cutting, taken from a tree, or a shoot from an old stool of an herb by being separated from the parent and placed in a situation favourable to its habit and condition. In its former station it only received a share of the nourishment yielded by a large system of roots; in its new place it depends on attachments to a youthful stem, or fibres formed by itself, and becomes an independent being, and expands in all the force of youth. So it is with a new planted young tree; by pruning the roots a set of new active fibres is produced, and by cutting-in the last year's shoots, when both are necessary, fresh ones come forth in connection with the new fibres, both progressing vigorously together.

This plain statement, sanctioned, moreover, by being pretty generally acted upon, is, nevertheless, very differently understood, even among practical men. There are two circumstances which have probably caused this difference of opinion: the first is, the imputed efficiency of the leaves in vegetable economy; and the second, an unheeded fact, *that old trees require less pruning of the head on removal than those that are young.* This latter circumstance, by the by, is easily accounted for, and is evidently as follows:—old trees, say of twenty or thirty years' growth, always contain a store of coagulated sap in their stem and branches; this becoming fluid on the

approach of spring, as is the case in all healthy trees, furnishes the requisite supply for the expansion of the buds and leaves, which is all that is expected of a recently transplanted tree of a large size. The summer is far advanced before intercommunication can possibly take place between the root and branches of such a tree; so that it may be said to live through part of the summer upon its previously received store of sap, without any assistance from the root at all. That this is a fact, may be inferred from what we may see every year in the timber yard, namely, vigorous young shoots produced by the butts of elm and other trees for a year or two after they have been felled, and consequently deprived of all assistance from their root. This circumstance has given some very intelligent planters reason to infer, that the more a large tree is pruned the worse it succeeds; and we have no doubt (in the case of several kinds of trees) the observation is just, provided the newly transplanted large tree can be kept perfectly steady in its new place.

Old trees are transplanted either for the purpose of embellishment, or to save the life of a favourite which happens to stand in the way. It is not expected that its volume will be increased on the instant; to preserve it in form and alive till it is re-established is the sole aim. Its bulk and inherent store of vitality render severe lopping of the head unnecessary. But with young trees we have other views; we endeavour to start them with renovated

strength by the means of a careful taking up, well prepared soil to receive them, and a judicious pruning of both roots and head, solely for the purpose of increasing their volume.

The old custom of severely lopping transplanted trees of considerable size was with the double intent of reducing the head to an equality with the damaged root, and to lighten it against the power of wind. This rule was oftentimes too indiscriminately and extremely applied; and, consequently, such severe dismemberment brought on a partial or total paralysis, which killed the tree. Besides, some forest trees cannot bear pruning at any time, unless the whole branch is cut smoothly off: such is the beech.

The foregoing remarks on the necessity of cutting in the head of a new transplanted tree in the first year are only applicable to young fruit trees, of the usual size and age, when taken from the nursery to the orchard or garden. On the general propriety of doing so, there need be no doubt; but the exact manner of doing it cannot be defined, because much depends on the condition of the tree, and the manner in which it is intended to be trained.

Young forest trees, when transplanted, require but little pruning; those of the *Coniferæ* none at all. Deciduous kinds should have irregular laterals cut off close, not only to give supremacy to the leading shoot, but to make the young tree less liable to be shaken by the wind.

Much has been written on the subject of trans-

planting large trees, and many wonderful feats in this way have been performed, both in ancient and modern times. Naked lawns have been diversified, and groves formed in the short space of a few months! Such performances go to prove that, with requisite care, skill, and physical force, properly directed, any tree of moderate size, *i. e.* from twenty to forty feet high, may be transplanted with safety and success. One precaution very much facilitates the execution; it is that of digging a circular trench, at a proper distance, say six or eight feet, round the trunk and deep enough to be below, and to cut through all the roots except three or four of the largest, which are left at equal distances to act as spurs for the better security of the tree when placed in its new situation. The trench, after the stumps of the roots are cut neatly off, is filled with previously prepared compost for the new fringe of fibres to strike into; and after one, or, what is better, two years, the tree may be with ease and a fine appendage of young roots taken up. In doing this a deep trench on the outside of the first is made, into which the mould among the roots is drawn, until the whole root is loosened from the soil. The spur roots are at the same time followed out and laid bare. A timber truck on high wheels is then backed against the stem, its pole raised and bound thereto; the wheels must be between, not upon any of the roots; and when all is ready a horse, or two if necessary, are hooked to the chain attached to the end of the pole, or to a rope fixed round both pole and stem

of the tree, by which the latter is pulled down upon the truck, in which position it is drawn away, root foremost, to its new place, previously prepared to receive it. In replanting the tree much depends on the care and order of laying out the roots, each in its natural direction, and all firmly embedded in the mould, giving water as the work proceeds till all is compactly covered up. As the tree will require to be frequently watered during the summer, the surface round the trunk should be left rather hollow to retain it.

It is generally observed, that trees transplanted during their most vigorous growth, *i. e.* after they are ten or twelve years of age, never arrive at so full stature, but take a precocious maturity of form long before they gain that age in which their characteristic form appears. This we sometimes see in pleasure grounds where large plants have been chosen for immediate effect. It is for this reason that very young trees are preferred by planters to large or older ones; and for the same reason also it is that trees, raised from the seed where they are intended to remain, always make more stately timber than such as have been transplanted at any time.

This is quite consistent with our ideas respecting the constitutional structure and development of plants. Every tree, shrub, or herb, according to the suitableness of its situation, has a determinate form and volume. They arrive at this through the different gradations of youth, perfect form, and full bulk,

whence they fall to decay. If they be transplanted whilst in the midst of the first stage a certain temporary pause must take place, inducing, no doubt, a consequent decrepitude, imposing the feeble exertions of age instead of the vigorous efforts of juvenile health.

Frequent transplantation of young trees and shrubs in the nursery prepares them for subsequent removal; and although this may affect the ultimate growth of forest trees in a trifling degree, it is highly useful in promoting early fruitfulness in those of fruit.

It is hardly necessary to add, that all plants are affected by the circumstances of soil and situation in which they are placed. A strong loam on a clay subsoil is suitable for the oak; a loamy gravel is best for the ash and elm; a calcareous gravel on chalk is the natural bed for the beech; and we see poplars, willows, and alder luxuriant in bog-earthy valleys.

All trees arrive at the greatest height in sheltered valleys; but in proportion as they gain altitude they are diminished in diameter of stem; the reverse of this takes place on exposed situations. The latter are also more hardy; and it is observed of both trees and shrubs of a luxuriant habit, that they withstand the effects of frost better than such as are weakly; and if the roots in both cases be securely defended it is also a protection to the head. This may be supposed to arise from the more copious currents of warm air received into the system through the roots.

Repeated transplantation of herbs has a tendency to increase their spreading or stocky bulk rather than their aspiring growth; as exemplified in many species of our culinary plants, as lettuce, broccoli, &c. The reason seems to be—their expansion, that is the elongation of their stem, leaves, and roots, receiving frequent checks, induces new births of roots, a shorter stem, broader leaves, and, in the case of most sorts of broccoli, larger flower-heads.

A very frequent error is committed in transplantation by placing the root too deep. This is well known to be hurtful to the plant; indeed so much so, that there is no readier way of killing a tree than by burying the roots.

SECTION III.

Propagation.—Nature has provided for the perpetuation of every species of plant found on the face of the earth, chiefly by dissemination, and also by viviparous progeny parted off from the parent station. Among all plants existing in a state of nature these processes go on constantly and uniformly without human interference; but when they are domesticated and brought into cultivation for the peculiar uses, directly or indirectly, of man, their original habits, forms, and qualities become so changed, that much variation ensues. Some of these variations are enlargements of the stem or of the leaves; others of

the flowers and seed, or of the appendages of the seed vessels. These variations, if considered improvements, are more or less valued, and consequently become interesting objects of the cultivator's care. Many variations which take place among herbs are perpetuated by their seed; but among improved fruits and flowers their seed, as has been before noticed, does not convey those variations in quality, form, and colour for which they are valued; and consequently the cultivator is compelled to have recourse to other expedients to preserve and continue the excellencies he regards.

Varieties are propagated by cuttings, layers, and by grafting and budding. All these practices have for their object the forming a new plant of the improved variety by placing a part of it in the ground to take root, or by grafting or budding it upon a kindred stock.

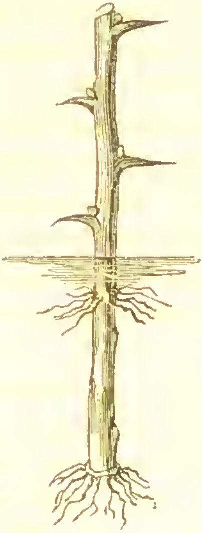
The methods of performing these expedients being so well known need not be described here. But as their practicability depends on the constitutional powers and organisation of the plants so propagated, these properties require to be noticed.

Cuttings.—All exogenous trees and shrubs may be propagated by cuttings, whether the stems be jointed or simple. Some kinds form roots readily from any part of the stem, others with more difficulty, owing perhaps to the resinous or some other quality in the sap, which soon becomes corrupt when placed, as cuttings usually are, in the soil.

The process by which a shoot or part of a shoot, a single bud, or even, in some cases, a single leaf, becomes an independent plant, is owing to the constitutional powers of the vital envelope of the system. This member, as has been before observed, possesses the faculty of protruding its lower part downward, or ejecting slender portions thereof into the ground, having all the members and powers of those roots which are produced from the corculum of a seed. The first roots produced by a seed proceed from that part of it called the rostellum, but how radicles are generated from the bottom of a cutting is not so easily conjectured. They issue from the vital membrane, but in what manner it is difficult to describe.

The proper depth at which cuttings should be put in cannot always be strictly attended to. Exotic cuttings, raised under the protection of glass, may, and commonly are, put no deeper into the soil than is suitable, that is just within the surface; but those of hardy plants are generally, for the sake of security, let in deeper than the ready striking of the cuttings require. It is worthy of remark, that the same distance below the surface which is so suitable for the healthy germination of seed, is also the most favourable for the ejection of the roots of cuttings. It seems that a certain modified influence of the atmosphere is necessary in both processes. Cuttings of gooseberries, common laurel, &c., when taken up after they are struck, appear rooted as Fig. 51,

Fig. 51.



showing that though roots are produced at the base, many are also emitted from the place near the surface above alluded to.

The advantages of propagating by cuttings is the ease and expedition with which it is done. Several kinds of trees and shrubs are raised from truncheons, *i. e.* large poles or branches, as the willow, elder, mulberry, &c.

The circumstance of shoots taken from the top of a tree so readily emitting roots when placed in a suitable situation, is proof that the principles of roots are present in every part of the simple stem, above ground as well as below. Whether the radicle fibre exists in an identical state in the envelope, or

whether it is a filamental protrusion of its substance only, is uncertain. We have stated repeatedly, that that vital member descends with more celerity than it proceeds in any other direction. Its appearance on the disbarked stem of a tree shows this decidedly; it flies from light, and seems to luxuriate in darkness. At the base of a cutting, it often issues out before the fibres are emitted; and sometimes a cutting will keep alive for several months, without other change than having this protuberance at the lower end.

It has been stated by some writers as a fact, that the fibres formed by a cutting, appertain to the buds situated above, in an especial manner. This idea has been alluded to before; and here we have only to repeat, that though extremely plausible, it is not easily proved. If, indeed, radicle fibres were never exhibited in the absence of buds, we might be led to adopt the opinion; but when we see simple leaves, those of the *Camèllia* for instance, emit a fringe of fibres without the assistance of either bud or stem, we are compelled to doubt its accuracy. That these essential parts progress together, and that they are intimately connected, is perfectly obvious; but they are distinct organs nevertheless. It may just be observed here, that the fibres produced from single leaves, appear to be ejected from the incised part of the petiole, which shows that slender portions of the envelope are even protruded into the leaves.

Cuttings of stove plants are sometimes readily rooted, by being placed in small phials of water sunk in the bark, or hot-bed. Experience has fixed the

rules, as well for choosing the parts of plants proper for cuttings, as the time for putting them in the ground. Those of trees and shrubs may be made of either the points, or any part of the present year's shoots, and put in the ground in autumn, or in early spring. Cuttings of delicate greenhouse, hothouse, or herbaceous flowering plants, are mostly made of the points of the growing shoots. There is in all young shoots of either woody or herbaceous plants, a certain part of them which more readily emit fibres than others; this is where it is not so tender as to be liable to rot, nor yet so indurated, as that the vegetative power is enfeebled. Heaths, and many other greenhouse and hothouse plants—pinks, and all similar plants in flower borders, are propagated on this principle.

Layering.—Plants which do not readily strike root by cuttings, are propagated by layers. The difference is, that whereas the cutting is completely separated from the parent, the layer is only partly so. It is a certain and safe process; because the layer is supported by the stool from which it is laid down, whilst new roots are exserted from an incision made in the shoot, to permit their escape. Layers, like cuttings, convey the true properties of the mother plant; for which advantage it is in many cases a superior mode to either grafting or budding.

One method of layering may be described, which is found particularly successful in the propagation of some flowering shrubs, viz.: the shoot to be layered

has circular incisions made above and below each bed along its whole length; it is then pegged down on the surface of the ground, and lightly covered with a sandy compost. Each bud will produce a shoot rising erectly in the air, and root fibres being at the same time ejected from the incisions, independent plants, separable in the autumn, are soon formed. The long sucker-like shoots of rose-trees are well calculated for this mode of propagation; and as some sorts of these eject roots sooner from young than from old wood, practitioners omit ringing the bark, and wait till the young shoots produced from the layers are five or six inches long: a tongue incision is then made at the bottom of each, and embedded in sand, they readily make roots; the old layer remaining to produce other shoots, which may be struck in like manner.

Grafting.—This is a very ancient custom. When the fruit-grower found that he could not continue his improved fruit by sowing their seed, he had recourse to engrafting a shoot of the favourite upon any wild kindred stock. The advantages of grafting are many, saying nothing of the facility and success of the operation—it induces moderate growth and early fruitfulness; instead of waiting a long period of the adolescence of a seedling, we have at once the matured head transferred to a young root; and if an old tree be of an inferior kind, or become decayed through age, it may be lopped, and regrafted with one or several new or superior sorts.

The practicability of grafting depends on the rea-

diness with which the cellular elements of the scion and stock unite. The envelope of the former impinging on that of the latter, at the season when both have begun, or are about to begin, to swell under the flowing sap, instantly amalgamate and coalesce. If the scion and stock be nearly of a size, the junction becomes so complete, that in a few years it is scarcely discernible, more especially if both are equal as to their habit of growth. But if one be of a more robust habit than the other, they increase in diameter unequally. If an apple scion be grafted on a whitethorn, or a pear on a quince stock, the grafts in both cases are engrossed much faster than the dwarfer

Fig. 52.

Perpendicular section of a graft inserted on a dwarf stock.

growing stocks; of course the junction is always apparent, and sometimes extremely dissimilar. This seems to be owing to the unequal character of the cellular and vascular fabric, as Fig. 52.

There is a free intercommunication of the juices; but the specific difference of the ligneous structure causes the disparity in the annual accretions. So with respect to a graft of a dwarfish or slender-growing species inserted in one of more vigorous habit, as the *Dàphne Cneòrum* on the *D. Laurèola*, the contrary effect takes place; while the scion puts forth its attenuated branches and feeble stem, that of the stock is incrassated to twice the size.

The sap-vessels on the bark and wood of both graft and stock being numerous, can hardly miss coming in contact when so united; and the prompt interjunction of the cellular matter anastomoses the whole together. On examination of the grafted part of a stem of several years' growth, by cleaving it perpendicularly, (Fig. 52,) or cutting it transversely, we see that there is an intimate union between the layer of wood, which was about to be formed when the operation was performed, and of all the subsequent formed layers of both; but between the wood of the graft and stock which was formed before the performance, although closely and soundly adhering to each other, there is a visible juncture, marked by a brown-coloured line where the two surfaces made by the knife were joined. The union of these is, however, no more than a simple adherence by means of secreted sap

acting as a cement, not certainly by interjunction of the ligneous fibres.

A very interesting problem on vegetable physiology is, whether the stock is affected by the graft, or the graft by the stock. In most cases, we observe no change whatever, any more than if the grafted tree had been raised from a cutting or a layer. No change takes place in its habit, nor in the form of its leaves, flower, or fruit. It receives from the stock apparently the same nutriment it would have received from its parent branch, supposing it to have been selected and left to form a principal head thereon. This is invariably the result of a union of congenial stocks and scions. But when this last-mentioned particular is not attended to, very different effects are observable. Some of these have been mentioned before, and which convincingly show, that the graft may be either invigorated or dwarfed by stocks uncongenial in habit with itself. The operation alone induces moderate growth; because in choosing scions we take, or should take, them from the mature and most fruitful parts of the tree we wish to propagate, and not from the rank growing shoots of the stem, or from the centre of the head. Plants have all natural habits; and some of them, fruit-trees among the rest, have what may be called incidental habits. The pendent position of the weeping ash, as before observed, is incidental. This deformity can be transferred by grafts; so any peculiar habit in the growth of fruit-trees may be transferred in the same way.

The crooked, dangling shoots of a jargonelle pear, for instance, should not be chosen for grafts ; nor should those of any other tree be selected which do not show the desired properties as well in habit of growth as in those of perfect health and maturity.

That the character of the stock affects the growth of the graft is well known. Rampant growing, and consequently barren fruit-trees, by being worked on dwarf-growing stocks, are greatly improved for the purposes of the fruit-grower ; and the reverse of this practice, i. e. placing weakly growing kinds on robust growing stocks effects a similar improvement.

These counter dispositions affect only the *growth* of the sorts united to each other by grafting ; but such unions produce other remarkable consequences. One of the most curious is the well-known circumstance of the variegation of the colour of the graft appearing on suckers which rise from the roots of the stock.

This circumstance shows that there is some intercommunication between the head and root, and must be, it is supposed, caused either by a descent of some member of the graft, or of its sap. No detachments of the wood or bark can possibly be prolonged downward ; because, as soon as these members are formed, they remain ever after unchanged longitudinally. The vital body is only capable of being so extended ; but whether as fibres, or in any other way from the graft or bud, it is difficult to conceive. If such a process obtains in the jasmine, we may expect that some-

thing similar might be observed in other trees. Such a circumstance, however, admits of easy proof, though it has not been sufficiently tried; because if we graft a pear on a quince, in a series of years the original axis of the quince stock will be covered by the annually or occasionally downward prolongations of the pear; and if then a cross section of the stem below the graft be made, the wood of the quince will appear in the centre, surrounded by that of the pear, the original bark of the stock remaining on the exterior. But that this does take place, is positively denied; no portion of the substance of the graft is ever seen to descend much below the place where it is united to the stock; and therefore some other cause must be assigned for the appearance of variegated leaves on the suckers.

A curious experiment, long ago performed by Du Hamel and others, has lately been made, by extracting a hoop of bark from the sycamore-leaved maple, and substituting another of equal size of red maple. A perfect union took place; and, after some time, the part was examined; and the new wood formed under the red maple bark was found to be that of itself, and not that of the sycamore, which it would have been had ligneous fibres of the latter descended from its buds above.—*Observations sur la Structure et la Mode d'Accroissement des tiges dans quelque Familles de Plantes Decotyledones. Par M. Adolphe Brongniart. Acad. de Scien. Paris.*

On this experiment we may remark, that it point-

edly controverts the idea that the new zone of wood is formed by fibres, which descend from the buds of the higher parts of the tree; and secondly, we may state our opinion, that the result showed that the vital envelope of the sycamore was removed with its bark, and that of the red maple put in its place, otherwise no new wood of the latter could have been formed beneath. Had the bark of the red species been placed on the *undisturbed* envelope of the sycamore maple, supposing this practicable, the new-formed wood would have been that of the last-named tree.

The difficulty about change of the colour of leaves is easily solved by saying that the taint (or disease as it is considered to be by botanists) is carried down by some partial subsidence of the sap. And though there may be rational doubts of the possibility of sap conveying *forms* from one part of the plant to another, it may be admitted that it is capable of conveying those chemical oxygenating qualities which may change green to yellow coloured leaves.

Certain influences have been attributed to the stock as either improving or deteriorating the fruit of the graft. It is said that pears from a quince stock are more austere than such as are produced by the common pear stock; and there are other accounts on record of apples being altered by the stocks on which they are worked. But none of these reports have been so far confirmed as to have any rule of practice founded upon them. One effect of double working fruit trees has been proved by nurserymen;

viz. that if a late peach be budded on an earlier kind, it will ripen sooner than if worked on a plum or common stock. This, however, may rather be the effect of double working, than from any precocious virtue it may receive from the intermediate stock on which it is placed.

Experience shows also that if a free-growing graft be placed on a diminutive growing stock, the roots of the latter will be greatly enlarged in consequence. This is a proof that the energy of the root is excitable, and in most cases depends in its development on the demands of the head.

The practice of cross-working fruit-trees has not yet been carried so far, perhaps, as it might be. This is a fine field for experiments which may lead to useful discoveries and important results; especially in the preparation of young fruit trees for forcing, or for houses or walls of limited extent.

Grafting is performed in many different ways according to the size of the stock to be worked, or to the susceptibility of the plant to succeed under such an operation. For large or old trees, *crown* and *clift** grafting are best adapted: the last is preferable, because there is greater security for the grafts against the effects of wind. Plants that do not readily take by the ordinary modes are grafted by what is called "grafting by approach," or "in-arching;" this is

* Both these methods of grafting are also suitable for very small exotic plants.

when the plants to be operated on stand near, or which may be brought near together, the shoots of each, by having equal sections taken off at the most convenient point of contact, firmly and exactly bound together, and clayed, will soon unite and allow of the graft being separated from its native branch. An ingenious and much more convenient method of grafting by "approach" has lately been practised. The graft is cut off the mother plant; but instead of the lower end being inserted into the stock, it is attached thereto by its middle and bound securely: a small phial of water is then suspended to the stock and in which the base of the graft is kept plunged. This supplies the graft with aliment till the connection between it and the stock is completely formed; and so effectual is this assistance to the graft, that fibres are produced from its lower end in the water, and of which (the lower end) a separate plant may be made when taken off.

Escutcheon, or shield grafting, is raising a triangular piece of the bark containing a bud, and inserting it into an opening of the same size made to receive it on the stock.

Root grafting is sometimes convenient. Instead of using the stem of a stock a root of it only is sufficient; this, grafted in the usual manner, tied and clayed, and replanted in a suitable place, will not fail to take. Where proper stocks cannot be had, a favourite plant may be propagated by grafting some of its shoots upon parts of its own roots which can

be spared for the purpose. *Much may be done in this way among exotics by an ingenious cultivator* who may have a hot bed to plunge his root-grafted plants into : such a stimulus greatly assists operations of this nature.

Whichsoever manner of grafting be adopted, the success principally depends on the congeniality of the stock and graft, on the proper season chosen for doing it, and on the precision and expedition with which the operation is performed.

Reverse grafting.—Nothing shows the anastomosing properties of the cellular membrane, when actuated by the vital principle, so convincingly as the instance of reverse grafting. By placing a graft on a stock in this unnatural manner a perfect union takes place and the future development of the graft is carried on in the same way as that of a reversed shoot. In this case it is perceivable that, if there be special sap vessels, they can re-convey as well as convey the juices either upwards or downwards ; or if there be no such vessels, it is evident, as has been before stated, that the cellular frame is permeable by sap in all directions. Another proof of this is exemplified by the long rambling shoots of the common bramble, which, as soon as their points rest on the ground, strike roots and assist to amplify the shoot by a backward flow of nourishment.

Budding—Differs from grafting in this, that, whereas by the latter, a shoot or part of a shoot

having *several visible buds* is transferred to the stock, by the former we transfer but *one*. Grafting is best performed in the spring just as the sap begins to be in motion; budding is done most successfully when the cambium or new layer of wood has gained considerable consistence, and from which the bark is easily raised. Some plants, chiefly our stone fruit trees, if wounded through the bark while the growth is stagnant, or before the living cellular matter of the envelope is in motion, do not readily heal. The wound becomes an inveterate sore, discharging for a long time the sap which becomes inspissated into gum by the air, at once exhausting the tree, and detrimental to the adjacent organisation of the system. Grafting such trees at the usual season, is therefore impracticable; but budding is eligible merely because the wound made in the operation is quickly healed, and the practice otherwise almost always successful.

Budding is only a modification of grafting, and succeeds upon the same principle being followed, viz. placing the vital members of the two plants in contact to form the desired connection. The bud to be inserted is cut off a properly ripened shoot, and after being freed from a thin slice of wood that comes off with it, is placed in an opening made in the bark of the stock to receive it. Thus it is placed in nearly the same situation on the stock, that it had on its native branch; the inner bark and vital envelope of the bud resting on the envelope of the stock; the outer bark of the

latter being first opened to receive and afterwards folded over the inserted bud, all being firmly bound by a ligature.

Some practitioners omit taking away the wood of the bud lest it should injure its woody axis, on the preservation of which the whole future development depends. This omission does not much signify, provided the bud be laid close to the wood of the stock, to do which the vital envelope must be raised along with the bark to admit it: but the better way is, certainly, to prepare the bud in the usual manner, and seeing that it is perfect, place it on the swelling envelope; which last should be disturbed as little as possible in the operation.

The effects of budding on the future tree, as well as in the circumstances arising from buds being associated with diminutive or rank growing stocks, are quite similar to those of grafting. By budding, a maiden tree is produced in the second year, by grafting, in the first. The former is suitable for all trees having a gummy, the latter for such as have an aqueous sap.

In the management of exotic plants, whether cultivated for their flowers or fruit, the effects of budding and grafting are of the greatest consequence to the cultivator. It has been shown that both operations induce diminutive growth; a convenient circumstance for our glazed houses of limited extent; and as grafts or buds are selected from the highest matured branches of the tree intended to be propagated, this

also gives a chance of seeing the flowers and fruit sooner than they might appear on an unworked plant. Tropical fruit trees seldom show flowers in our collections, because there is not sufficient space allowed them for that expansion of branches which usually precedes the production of fruit: therefore, whatever tends to diminish their natural stature, and expedite their flowering, is a requisite point of good management.

Pine-apples we can have in this country in as great, if not greater perfection than in their native climate; and this because they are not a tree fruit, require but little space, and quickly arrive at full age. The peach, grape, and fig, are almost naturalised, and need only the protection of a wall assisted by a glass case to ripen them. The orange and its affinities require only to be defended from frost. But the mango, mangosteen, jambosteen, cherimoyer, and several other excellent tropical fruits have not had in Europe, perhaps, that management of which they are susceptible, nor care bestowed which they deserve, and which, doubtless, would effect their maturation in our pineries, or, in what would be better, a stove constructed for the purpose. It is among these last mentioned fruit trees, that the skill of the gardener with his knife and working operations (i. e. grafting and budding) would effectuate so desirable a result; and the practicability of such manœuvres only requires to be mentioned to induce proprietors who have the taste and means, and the gardener who has opportu-

nity to make the trial, in order to add to the delicacies of his employer's table.

The only other methods of artificial propagation are performed on herbaceous plants. Bulbs which do not produce offsets readily, or from which offsets are required, are managed so as to yield them plentifully by cutting off the upper half of the bulb. This prevents flowering and prompts the viviparous principle into extraordinary action, so that a numerous progeny are produced. Tubers having many buds, or eyes as they are called, are separable into as many sections as there are eyes, so that they may be propagated to any extent; and to show the vast complication of gems existing in a tuber of, or in a single eye of a potato, we have only to instance the means pursued to multiply a new or favourite sort when only a few, or a single one is possessed by the cultivator. In the month of April, or earlier, the tuber is placed in a mild hot-bed; and as soon as the shoots that rise in succession from it are three or four inches long, they are slipped off and planted out in open ground. This planting of slips may continue till the beginning of July: for so long will the tuber continue to throw up shoots in number almost incredible; each eye throwing up many stems, which are all separable as independent plants; and, thus detached, yield a far more numerous return of tubers than would have been produced by the mother disposed of in any other way.

Tubers of congenial natures are capable of being grafted on each other, and are sometimes useful in the

propagation of curious varieties of *Georgìna, Pæònia*, and the like.

SECTION IV.

Pruning.—The pruner should be a good vegetable physiologist; unless he has an intimate knowledge of the components of the plant—their tendencies and functions in the system, his operations will always be performed in the twilight of uncertainty. There are, however, many expert pruners who have no pretensions to be called scientific physiologists, and who, notwithstanding, perform the work with the utmost propriety, merely because they have been taught the art by a good master. Practical experience will enable any man to become a proficient in pruning and training, who may remain his whole life in ignorance of the motion of the fluids, or of the manner of the changes which take place in the tree he prunes. But every practical man will do well to study and make himself acquainted with the physiology of plants; it will enable him to trace many effects which occur in his practice to their real causes, and free his mind from all doubt as to the practicability or impracticability of whatever he may wish, or find it necessary to do.

If we except the failure of the lowest branches of trees, there are few indications in nature showing the necessity of pruning. In natural forests trees gene-

rally grow closely together; of course their lower branches, being deprived of air and light, quickly perish; but when by accident they stand singly, the lower branches are as permanent as those of the top, and even more so, and moreover appear to be as necessary a part of the system. When, however, trees are taken under the care of man they are subjected to controul, and are trained to answer the purposes for which they are cultivated, whether that be for the timber they supply, the shelter and ornament they afford, or for the fruit or flowers which they yield. For these different objects trees undergo various manipulations of the pruner, and which may be separately considered.

Forest-tree Pruning.—Forest trees are regarded either as objects of ornament or of profit; sometimes used as screens, for shelter, or for fences. Ornamental trees require no assistance from the pruner. Natural forms cannot be improved by art or by the most refined taste. It is only in woodlands, raised and maintained as sources of profit or income, that the skill and exertions of the forest pruner are available. Here the special object is to obtain the greatest quantity of marketable timber. With this view he endeavours to prune his trees so as to form stately, straight, and clean-grained boles, standing as closely together as will allow every tree a sufficient share of air and light. This disposition as to interdistances, and the desired form of bole, can only be obtained by giving attention to the trees in the early stages of

their growth. To have timber of the finest grain and quality, no lateral branches should be allowed to arrive at any considerable size, that grow within the convenient reach of the pruner. They act as rivals to the principal stem; and if after they are seen to act thus injuriously, they be cut off, the wound thereby made is so large that a flaw in the timber is the consequence. The soundness of timber is not deteriorated by pruning, provided the wound made in lopping be no greater than will be covered by new bark and wood during the following summer. A scar made by the axe, bill, or chisel, if exposed longer than twelve months, will always be a defect in the timber; for though it may be afterwards covered smoothly over by the new collapsing wood, it is impossible that any perfect union can take place between a surface of timber exposed to the air for six months, and that which is subsequently formed over it.

Forest pruning is generally performed in the winter; all wood work (except oak, larch, &c., felling and peeling) is done in that season, chiefly because the leaves are off, and the growth at rest. It is necessary to state, however, that lopping performed in the beginning of summer would be a better practice for the good of the trees. The reason is this; wounds made in winter do not immediately begin to be healed by the collapsing wood, which in time will be spread over them; because that member of the system which is alone capable of closing a wound is then torpid, and the exposed wood of the wound is

unprotected for several months; whereas if wounds be made when the vital member or envelope is every day extending itself they are sooner closed, and if not very large, completely covered before the growth ceases in autumn, or, at any rate, early in the following summer. It should be a rule with the pruner never to make a wound that cannot be closed in the course of twelve months; but he can only attend to this rule by a timely application of the knife or chisel. A hand-saw should never be used in pruning forest trees, because if the irregular branch be so large as to require this tool, it had far better be left where it is. Very tall and handsome boles may be formed by the assistance of long ladders, hand-saws, and jack-planes; but though these large and carefully polished wounds will be in a few years covered with healthy bark and wood, the internal scar will ever remain a flaw in the timber. (Fig. 53.) These circumstances show at once the absolute necessity of pruning at an early age of the tree, for though all

Fig. 53.

Section of a stem of sixteen years' growth, to show the effect of pruning off a large branch in the tenth year.

have a specific character of growth, with a more or less branched head, which they naturally assume when at liberty so to do, they submit to the direction of skill, and many trees of bush-headed character may be trained into a light and aspiring shape, with a well-proportioned length of bole.

To take care that every tree has a principal leader is a material object of early management, and to maintain its superiority in the future growth, a chief point to be attended to. All laterals that show a rivalry so as to divide or deform the axis or main trunk, should be displaced; and before they attain such a size as to endanger its soundness by removal. Very small branches or spray need not be removed from the stem; whether they live or die they cannot deteriorate the timber.

Forest-tree pruning may be continued till the plants are twenty years old or more, after that time the trouble and expense of the business makes it inexpedient; but if they have been judiciously pruned up to that age, sufficiently fine forms will have been given, and proper length of stem secured.

A great deal has been said relative to the propriety of lopping trees as a means of increasing the size of the bole. The question lies in a nut-shell: the larger the head be, the greater must the trunk be also: the diameter of the latter is formed by the number of branches which are or *have been* produced by the former. In proportion as the roots increase, in like proportion are the stem and head extended. Severe mutilation of the head paralyses the energy

of the roots, and *vice versâ.* Reducing the number of branches to give magnitude to the stem is ridiculous. Regulating the growth of the branches by stopping or cutting out such as are over luxuriant gives supremacy and a direction to the leader; but this gives no magnitude to the trunk. Every individual twig of the head is a part of the stem; the former could not be developed without assistance from the latter, which, while it conveys support, is increased in some degree to enable it to do so. In fact, every member of a tree depends on, and in its turn lends assistance to, every other, when all are in perfect health. The only exception to this as a rule is an accidental luxuriance, sometimes exhibited by a single branch and a certain division of the root, which will progress together for several years before the rest of the tree. (Fig. 54.) For such irregularity, however, no good reason can be assigned.

Fig. 54.

The foregoing remarks are applicable to deciduous trees only; and with respect to them the forester has only to bestow the necessary attention for a few years to give the desired form while they are within convenient reach; if the vigour be properly directed in their youth they will seldom fail to grow up handsome and valuable timber trees.

As a rule, every branch which shows a rivalry to the leader should be displaced by the knife or *turning-saw*, close to the stem, as soon as it has attained a diameter of one inch; such a wound will be quickly healed, and without risk of injury to the timber.

As the different kinds of forest trees are used for various purposes, the forester endeavours to supply the various demands. It is wrong that any advantage derivable from woodlands should be left to chance. Some tradesmen require the straightest and clearest grained oak for planking, beams, posts, &c. Besides this, in the dock yards, cross-grained butts and knee timbers are in request, and consequently valuable. The former description of oak, as well as that of all other trees, is obtained in the shortest time by a rather close order of planting, and early and careful prunings and thinnings if requisite; the latter by open planting and partial pruning; that is, not by aiming at a tall smooth bole, but by leaving the branches in sets, as it may happen, of three or four diverging from one place, and clearing the stem of all intermediate branches and spray between the sets. This style of pruning, though it has never perhaps been executed, is, nevertheless, quite practicable; it is only pruning the oak

to resemble the disposition of the branches of a fir tree, only with greater distances between the tiers.

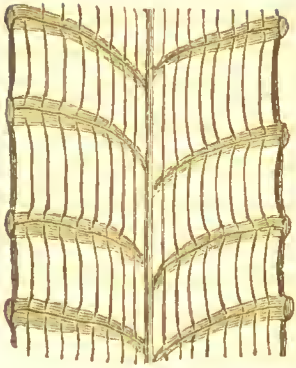
Fir timber for the use of builders and mast makers cannot be too free from knots, and it is impossible to have it so, unless planted and trained up in the closest order. When so disposed no lower branches can live to distort the longitudinal structure of the bole. The centres of the trunks when cut up for use, only show the bases of the first laterals; but every concentric layer of wood imposed after these first branches decay is free from knots. (Fig. 55.)

Fig. 55.

Vertical section of a tree, the lateral branches of which had consecutively died, or been cut when three years old.

A single fir requires a large space, and produces the worst timber; its first branches continue to enlarge and extend themselves, sweeping the ground as long as the stem continues to rise; and though the latter arrives at a great size, its timber is of the most inferior description, being deteriorated by large knots. (Fig. 56.)

Fig. 56.



Section of a fir tree which has never been pruned, supposed to be cut through opposite branches.

In fact, fine grained deal cannot be produced unless the trees are planted, or chance to stand so closely together as to prevent all extension of branches. All sorts of the pine tribe intended for profit should be planted to grow up, and, like a field of corn, be all cut down together. Such plantations do not admit of being gradually drawn, except when very young. They may be called, on this account, social trees; for as soon as the unity of the congregation is broken, the exposed trees, for want of their wonted protection, not only cease to thrive, but many die. Firs planted for ornament should stand at forty or fifty feet distances; otherwise they cannot show the grandeur of their forms. The pruner must not touch them; his interference only tends to make them the most ugly objects in the vegetable kingdom. Planted as nurses in young woods of deciduous trees, they are kept

within due bounds by a very simple method of pruning recommended by Mr. Billington, viz. by pinching off from time to time the leading buds of the branches. This induces a spray-covered, rather than a naked stem ; and prevents the encroachment of the branches, without destroying their character as nurses. By the same means, fir trees may be formed into impervious screens, or sheltering hedge-like boundaries ; very useful in many cases of rural improvement.

Ash timber is produced of superior quality by being grown in close order ; its toughness and clearness of grain makes it enviable material for the coach maker. Straight, smooth sticks of ash, fifty feet in length, and from eight to twelve inches diameter, are highly prized by all machine makers. Whether for timber or underwood this tree should always be grown in plantations by itself ; not only because of its greater rapidity of growth, but because it is a most noxious tree in hedge rows, or as standing single in corn fields or meadows.

Oak and elm are best suited for hedge rows. It is incredible how much elm timber can be raised in hedge order. And as the superiors are cut down, a constant succession of young stems are rising from the old roots. No tree bears pruning so well as the elm. So severely is this executed in Middlesex and elsewhere, that a very small branch only is left at the top every time the tree is shredded. This property of being unhurt by wholesale pruning, is owing to the vivency of the tree which, being every where studded

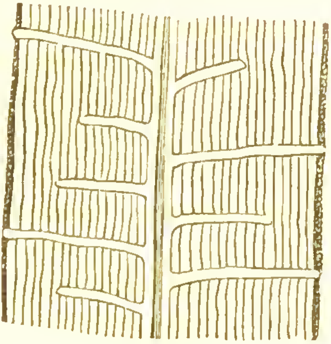
with latent buds, throws out a numerous spray over all the stem; and, though unequal to increase the diameter of the trunk as a large branched head would do in the same time, yet it gives the wood a gnarled character particularly useful for the naves and fellies of carriage wheels, and other purposes where liability to split would be a defect.

Ages had elapsed before forest trees were considered as objects worth the expense of pruning; but during the last century, the great demands made upon both public and private woods and forests, and the great quantities of defective timber rejected at the dock-yards, at last called attention to this neglected branch of rural economy. The defective state of oak timber was attributed to the want of pruning. The rotten stumps of branches which had been torn off by the wind, and which in their decay admitted water into the trunk, were said to be the cause of the disaster. Pruning was therefore had recourse to; but a bad style was introduced, viz. cutting off the lower branches at the distance of two or three feet from the bole. This plan was soon given up; not only because it disfigured the tree, but also because many of the stumps dying, the same defects followed this practice as were complained of before it was had recourse to. Close pruning was next recommended; but with no good result, as has been previously shown. A middle course is now adopted, namely what is called *foreshortening*. This method preserves all the branches, but the lower ones are kept back, by having their leading shoots repeatedly taken off. (Fig. 57.)

Fig. 57.

This is particularly suitable for hedge-row timber, as it prevents the trees from overshading the land. It must be observed, however, that though this method gives *soundness*, it does not produce *clearness* of grain, which is the grand object of pruning. (Fig. 58.)

Fig. 58.



Section of a trunk which has been foreshortened, showing that clear grained timber cannot be obtained by this method of pruning.

Lopping.—In countries where fuel is scarce or dear, hedge-row trees are pollarded and periodically lopped for domestic purposes, and for fencing-stuff. Oak, elm, and ash, are chosen for this barbarous purpose. The boles are preserved as the property of the landlord, and the loppings that of the tenant. The trunks soon become hollow, and consequently useless as timber. Willow pollards are extensively planted and maintained in low meadows. The great advantage of growing poles, stakes, and headers, for fencing in this manner, is, because they are out of the reach of cattle, requiring no fencing, as a piece of land occupied for the same purpose would do.

Willow-holts, for supplying basketmakers' rods, are usually cut every year. In this management it is observable, that every new crop of shoots are perfected by a new growth of roots. The centre of a willow pollard, and that of a stool soon decay ; and in the rotten mass, roots from the superior buds and shoots are seen to strike and luxuriate. The spectacle of a hollow willow-tree being partly filled with roots, which, from time to time have descended from the shoots of the head, gave Dr. Darwin, it is probable, the first idea of the wood of the stem being formed by descending radicles from the buds. But this example of the willow, when duly considered, is no corroboration of the doctor's notion. The shoots of willow, or of any other tree, it is perfectly true, are prolonged by the assistance of radicles simultaneously produced. The doctor's idea is, that these two members are immediately connected, and that

the latter are actually produced by the former, as in the case of a single eye of a vine struck as a cutting; forgetting, that in the case of a pollard, or any other tree, an intermediate vital member previously exists to form the connection; and which is constitutionally calculated to allow intercommunication between the moving extremities, without any portion of the shoot descending to the root, or any part of the latter, except juices, ascending to the former. The intermediate channel is the vital *indusium*, containing a compages of sap vessels, which, while they conduct, are themselves enlarged by the impulse and qualities of the rising current *.

An argument in support of heading down young and judiciously pruning old deciduous trees, may be drawn from the natural history of many sorts of willows. They are not constituted to be permanent trees. So far from their bulk, number of branches, and *quantity of foliage*, being incentives to increased vegetative power, an exactly contrary effect is the consequence. As they increase in size the more

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* This circumstance deserves the notice of those physiologists, who assert that "the matter" (?) which enlarges a stem descends. Because as no upward or other current can be generated unless there be an outlet or reservoir and as the bursting buds, lengthening shoots, and respiring leaves, are these outlets, why may not the sap be deemed capable of enlarging and distending the stem in its ascent, as well as attributing the enlargement solely to it, (or some other matter,) in its descent?

feeble is their growth, till at last all vitality ceases; whereas were they repeatedly cut in, new powers would be imparted to the system, and by calling forth latent principles of life, continue it for an indefinite length of time. The common furze, (*Ulex Europœa,*) requires to be frequently cut, or eaten down to keep it alive. The alder is short-lived, but may be reproduced successionally for ages.

In concluding this section on forest-tree pruning, we may add, that in all cases where large branches, from some accident, require to be cut closely off, the wound should be covered with some kind of plaster, such as grafting clay, or, what is better, a composition of three parts cow-dung and one part sifted lime. This spread on about half an inch thick, and afterwards dusted with lime to prevent its being washed off by rain, will be found useful, not so much for preserving the naked wood, as for accelerating the expansion of the vital envelope, which, as has been observed before, extends itself much faster *in darkness,* than when exposed to light and dry air.

Underwood Pruning.—Besides timber trees, woodland consists of underwood also, which is felled periodically. The most profitable trees for this purpose are Spanish chestnut, ash, Huntingdon, and other willows; but oak, alder, birch, and hazel, are also serviceable. Beech and hornbeam are also grown in this way, chiefly for the charcoal manufacturers.

But who would think of pruning underwood? a

work never thought of, much less performed. Notwithstanding this, there is, perhaps, no labour of the forester that would better pay the cost.

When a fall has been made, and the stuff all cleared away, the new growth is left to rise as it may. A far greater number of shoots are produced by the stubs or stools than can possibly come to perfection. A major part are underlings, which never rise to be useful for any purpose, being ultimately destroyed by the superior shoots. Hence much redundant, crooked, and irregular growth is produced; the strength of the stools unnecessarily wasted, and consequently injured.

To prevent all this waste and irregularity of growth, the underwood should be gone over at the end of the first or second year after the fall; all the most promising shoots selected to stand, and regulated as to distance and position, and every supernumerary displaced. At the same time, all useless plants, as briars, ivy, and travellers' ivy, (*Clematis,*) which rob and encumber the trees and young growth, should be cut down or eradicated.

This pruning may be considered a tedious and unnecessary task; but the very superior stuff obtained by this management, would soon convince a proprietor of its great advantages as productive of profit.

Fruit-tree Pruning.—The different methods pursued in the cultivation of our superior fruit-trees, render annual pruning necessary. Artificial forms

in forcing houses and frames, on walls and as espaliers, in which the naturally rotund form of the head is dilated on a superficial plane, make the use of the knife indispensable. We not only endeavour to make a tree fruitful, but must also keep it within the bounds allotted to it. Confined to the artificial position imposed, the tree is ever endeavouring to regain its natural form by the production of fore-right shoots or breastwood. Part of this is preserved to fill up vacancies, and to keep up a due supply of bearing wood in every part of the tree; the rest is periodically cut away.

In this requisite treatment it is, however, better to *direct* the growth by displacing irregular or redundant shoots on their first appearance, or even while in the state of buds, than to allow many shoots to be produced which must ultimately be cut off. Such manipulation can only be executed on such fruit trees as are so placed as to be under immediate control, viz. all trees in houses, on walls, espaliers, or such other dwarfed forms as may be adopted in the garden or orchard. In this business the manager has to distinguish between the treatment necessary for the encouragement of the general growth of the tree, and that *subdued degree of it* which is requisite to its fertility, and the reduced volume which its limited situation and artificial form require. If both the root and head be allowed to advance without a sufficient check, both will be excited into greater action than is suitable for its limited space, and the knife

must be applied to keep it within bounds. But the tree which is only kept within bounds by annual dismemberment, will, like the willow before spoken of, be, like it, prompted into unnecessary luxuriance unsuitable to the purpose for which the tree is cultivated. The main point to be aimed at is, as soon as the tree has nearly covered the space designed for it, to keep it in that moderate state, which, while it possesses health and sufficient vigour to produce a crop of fruit, and yield a supply of young wood necessary for succeeding crops, is all that is requisite.

By thinning the buds or young shoots early in the spring, excessive growth is repressed, and a qualified expansion of the whole system induced. It is an old saying, "the more you use the knife the more you may." This, however, is spoken of severe winter pruning, which on many trees causes exuberance in the following summer; but preventing the summer growth by reducing the demand upon the root, has a contrary effect. If every shoot produced by a peach tree, for instance, were suffered to be perfected, a thick irregular mass of brushwood would be the consequence; a corresponding extension of the root takes place at the same time, and which would stimulate still more the growth of the next year, whether this mass of brushwood were pruned off or not.

To avoid both extremes is good management; encourage moderate growth by allowing a middling

number of rightly placed shoots to be perfected, but no excess or paucity should appear.

This, however, being, as before observed, an artificial state of the tree, the art of pruning (by which is meant both winter and summer thinning) is in no case required to be executed with more precision than in the management of our forced and wall fruit-trees.

It has already been said that the manner in which a tree bears its fruit directs the pruner's operations. The fruit buds of peach, nectarine, and some kinds of cherries, are borne on the young moderate sized shoots of the previous year. Of these, in the summer regulation, an abundant supply are selected and preserved by being carefully fastened to the wall or trellis, if so trained. At the winter, or rather spring pruning, the pruner has two special objects in view, first, to secure a full supply of young shoots to enlarge, improve the symmetry, and fill up vacant parts of the tree for the crop of next season; and, secondly, to keep a sufficient number of bearing shoots to yield the crop of the present. A judicious use of the knife obtains both these objects, and the result shows the necessity as well as the excellence of the art.

A good pruner regards the regular form and equal distribution of the bearing wood, rather than an increased number of fruit which, by leaving some promising shoots, might be obtained in any one season. When the tree is getting thin of bearing

wood, there may be a few promising shoots thickly beset with flower buds: these, however, would not be preserved for their fruit, but cut down to produce a greater number of young shoots for the service of the next and following years. There is no depending on old branches of peach and nectarine trees for the production of young shoots, though this does occasionally happen; the lowest placed young wood of the above trees is therefore preserved in order that there may be a constant succession from the bottom. It has been stated that the vital envelope contains the principles of buds as well as of roots, and as some trained trees, particularly peaches and nectarines, are liable to lose their lower branches, it is always desirable to bring forth young shoots from the naked parts of the stem or branches. This may sometimes be accomplished by art, though the trees here mentioned are the least tractable of any for obtaining such result. The manœuvre is to cut a notch through the bark, immediately above the place where a shoot is wanted, and removing carefully any dead scabrous bark from the lower side, latent buds may be prompted into action. May is the best month for performing this on stone-fruit trees, and at the time of pruning for others. But the same object is more certainly obtained by the insertion of buds, or grafts, at the usual seasons.

Here we may observe, that besides a proper thinning of shoots, thinning flowers is sometimes expedient. Taking off redundant fruit is an every-day

practice; but regulating the number of flowers is not so much practised as it should be. There is an evident connection among the fructiferous gems, even before their expansion. The whole may require a greater amount of nutrition than the tree is able to supply for their perfect expansion; but by reducing the number, selecting the best placed and most promising, the residue will certainly come forth with greater vigour, and consequently would more likely set their fruit, as well as be followed by that of increased size. The morella cherry, and several other fruit trees, are lavish of flowers, which must exhaust the tree; and it is said that thinning them with scissors before they blow well repays the labour. Disbudding trees of their style of bearing, would, however, be an endless task, and indeed unnecessary, as the same object may be gained by a freer use of the pruning knife. Destroying flowers is not a pleasant affair to the anxious manager; he would be inclined to thin the fruit rather than the flowers; both, however, may be done with advantage, especially in respect of weakly growing trees.

Although the manner of bearing defines the plan to be followed by the pruner, yet this may be departed from. Those trees that usually bear their fruit on longer or shorter portions of the last year's shoots, as the peach for example, may be pruned in such a manner as to be made to bear on shoots so shortened as to resemble spurs. This mode of pruning may be described in a few words:—The tree is trained

in the fan manner, and rather in close order: the extremities of the leading shoots are always carefully prolonged, till the space allotted for the tree is occupied. Along the branches numerous shoots are annually produced: a proper number of these at due and regular distances are laid in close to the wall between the principal branches, and the rest displaced. At the spring pruning the preferred shoots are loosened from the wall, and cut down to an inch or two in length, and tied to the branch if necessary, leaving the spaces between the branches clear for the reception of the summer shoots to be trained in as before. The curtailed shoots bear the fruit in great numbers, and of fine quality. This plan is called the *mother-branch* style, by French gardeners, and is highly recommended by an able practitioner * in this country.

The grape vine may be similarly managed; its fruit may be produced on very long or very short last year's shoots, like spurs; indeed from neither, but from latent buds seated at the nodes of the old stems; but, strictly speaking, the fruit of the vine is always borne on the shoots of the present year.

The long shoot method of training and pruning may be performed in the open air, or in houses; but it is most commonly practised in pineries, or other houses, where the vines are only trained to each rafter. Each plant has one bearing shoot the whole

* Mr. John Seymour.

length of the rafter ; this is destined to bear fruit only, no other growth being suffered on it, except the bases of the side shoots bearing the fruit, their points being pinched off immediately beyond, and one succession-shoot trained from the lowest part of it. When the fruit is all gathered, the whole of the shoot that bore it is cut away, and the young succession shoot takes its place, to be treated in a similar manner in the ensuing year. This method of pruning the vine is exactly like that practised in pruning the raspberry ; the shoots that bear the fruit this year die, and are cut away to make room for the bearing wood of the next. This alternate, or rather successional plan of managing the vine, may be continued for many years ; and if the plant be kept vigorous and well treated, generally with great success. The principal attention required is to cause the lower buds to burst simultaneously with those situated above ; because the vine, like other trees, commences growth at the top, and as this part of the shoot has also the greatest excitement from the higher temperature of the upper part of the house, it will very naturally happen, that the upper buds forming outlets for, and attracting a chief share of, the rising sap, deprive the lower of their due portion ; hence the latter are liable to remain inert.

As this is always an unprofitable, as well as an unsightly defect, cultivators practise various means to effect a general movement of all the buds from top to bottom as nearly at the same time as possible.

One of the means employed is by reducing the number of the buds; that is, at pruning time, to cut out two-thirds of them. Calling the topmost bud one, cut out two and three, leave number four, cut out five and six, leaving seven, &c., all the way to the bottom. This disposition of the buds will be found alternating with each other very regularly, as well in position as distances; and though the number of bunches be reduced, the weight of the crop is not so; because the buds that remain come forth with increased strength, and yield larger bunches of fruit. Indeed, for a tree trained on such a limited scale, one third of the usual number of buds is as many as the plant should be allowed to bring to perfection *. Even in this method of equalising the development of the buds, the upper ones will precede the lower; but the former being stopped immediately beyond the fruit, or removed entirely if barren, causes the lower to burst in succession downwards.

Another expedient to induce every eye upon a long shoot to burst at the same time, is by bending it into a zig-zag direction, or serpentine position on the

* That the strength of fruit-trees is exhaustible by heavy crops is well known; two very plentiful ones very seldom following each other. No tree, therefore, that is within convenient reach, should be allowed to overweaken itself in any one year, more especially very young trees in houses. The increased size and excellence of a moderate number, which at the same time does not enfeeble the tree, is always preferable to great numbers of inferior size and quality.

lower part of the rafter; this effects a retardation of the upper buds; by the whole being in nearly an equal temperature, each bud has a more equal share of the vegetative impulse. When all are by these means put in motion, the shoot is then put up in its place. There is another device practised to cause all the buds on a long shoot to burst at the same time, that is, by bringing it down to a horizontal position till all have begun to move; which, when this is effected, the shoot is again put upright. This result, like the foregoing, is attributable to the equal temperature in which the shoot is placed, and to the unnatural position of the shoot.

Vines cultivated in pineries never have, in consequence of the high temperature constantly maintained, that degree of hybernation, which, as natives of the temperate zone, they require; of course they become exhausted by the continued excitement. To obviate this, some pineries are so constructed, as to admit of the vines being shut out of the house during winter, and taken in again at the proper season.

When the vine is made to bear its fruit from short shoots or spurs as they are called, the first shoots are treated as has been described of long single shoots; only instead of this being entirely cut away to be succeeded by a new one, it is left, and no successor is trained up. Instead thereof, the short laterals that have, or should have borne the fruit, are cut back to two eyes, whence the shoots and fruit of next year

are produced, and stopped at the joint above the fruit as before: these, in their turn, are cut back in the year following, and again and again, so long as they continue fruitful, and do not overshade too much the interior of the house.

When the practical man is employed in thus dressing the vine by divesting the tree of all leading and superfluous shoots, for the express purpose of enlarging and perfecting the fruit at the summit of every shoot, he is puzzled to understand that dictum of science which affirms that "the matter" which increases the stem and fruit thereon, "*descends:*" because if this maxim be right, his practice is evidently wrong. So must stripping gooseberry and currant trees of their summer shoots, with a similar view, be injudicious. But in the case of the vine, it is not likely that such management will ever be abandoned.

But a remarkable property of the vine is its power of yielding fruit from latent or invisible buds, provided the stem be in a suitable situation for receiving sufficient air, light, and heat. In a former part of this volume it has been assumed, that terminal flower buds require periods of one, two, or many years to perfect themselves before expansion. Here we have an instance of latent buds issuing from the nodes of the old stems without exposure to either air or light, save what they receive through the vascular structure of the stem itself. This, however, is, it appears, sufficient for the preparatory maturation of the fructiferous parts of the vine. The difference in the con-

stitutional arrangement may, perhaps, account for the dissimilarity between the pear tree and the vine. The flowers of the former are terminal; those of the latter, lateral. The first have the common pedicle seated on the pith, the last on a lateral prolongation of the wood, which, if unfertile, resolves itself, as before observed, into a tendril.

In this hand-smooth style of pruning the vine many more shoots are produced than it would be prudent to leave; a few only at each joint are chosen, and the supernumeraries displaced. It is always in the power of the pruner either to have a few and large fruit, or a greater number of smaller; this is determined by his own special purposes, or by the vigour and capability of the tree *.

Of all fruit trees, whether in houses or elsewhere, the vine is the most tractable and easy of management. Erect in different gradations; with an upright stem and horizontal branches, or with an erect stem and the branches trained from two top horizontals downwards; an excellent method for furnishing the naked parts of the garden walls between the dwarf trained trees. In fact vines may be led in any way, and so as their shoots have sufficient air and light, with the necessary summer care, always succeed in a suitable temperature.

Left to itself the vine is a most disorderly grower; the shoots are furnished with both tendrils and lateral

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* It is right to observe, however, that this method of treating the vine is rarely practised.

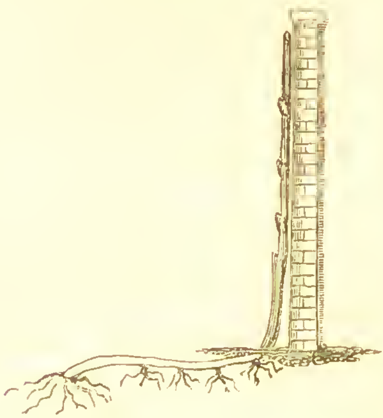
shoots, which require constant removal in house or wall management. The tendrils are a useless appendage if the vine dresser does his duty. The lateral or water shoots* are somehow connected with the organisation of the principal buds; because if they be trimmed off from the leading shoot when it is growing strongly, the bud at their base will very frequently burst, and consequently be lost for the service of the following year. To prevent this, the laterals are stopped above their first joint, which will hinder unnecessary exhaustion of the tree, and at the same time not injure the principal buds, on the preservation of which the crop of the next year entirely depends. At the pruning season these laterals, if any be left, are cut closely off. Here it may again be necessary to repeat, that the summer dressing is to check the natural luxuriance of the tree, confine the sap in the desired channels, and give a full supply of this to the crop of fruit. Vine dressing is even extended to regulating and thinning the bunches, in order that the berries may swell to a full size, and be not injured by bearing too closely on each other.

Connected with the management of the vine may be mentioned a method of planting it practised in some parts of France, and which deserves to be noticed. It

* It is said that some kinds of the grape vine in the south of France produce second crops; the last from the laterals of the principal shoots. This circumstance occasionally occurs in our hot-houses where the trees are very luxuriant. But neither is such fruit, nor such property of the tree, worth the notice of British cultivators.

is well known, that to have short jointed and well ripened wood, high temperature and abundance of air and light are everywhere indispensably necessary; and we find by experience, that to have perfectly mature and high flavoured fruit, the roots should have an extensive horizontal range, and be under some influence of air and the heat of the sun. To obtain these advantages some French gardeners, instead of planting the trees close to the wall, as is the common practice, place the root at the distance of six or eight feet, the stem or stems being laid along towards the wall a few inches beneath the surface, and then brought up and trained thereto. This position enlarges the system of roots near the surface, and enables them to yield increased supplies not of watery, but of well aërolated sap. (Fig. 59.)

Fig. 59.



Vine borders in this country have been formed on a plan somewhat similar, with a view to obtaining the

assistance of the sun's heat and full air for the roots; and with the greatest success. This is done by laying a bed of gravel, if no such thing exist naturally, twenty inches from the surface, on which a vine compost is laid about fourteen inches thick, and over this the gravel, to form a walk of good width in front of the vinery.

Fruit trees which bear their fruit chiefly on the shoots of last year's production, are pruned so as to allow of being trained in the fan manner; and though the spur-bearing trees may and are also trained in the same way, yet as low espaliers, or on low walls, they are most commonly trained horizontally, i. e. with the stem erect, whence lateral branches are led in opposite pairs. Trees so trained have a neat symmetrical appearance, and may be continued to a great distance on each side. The only drawback on this style is, that the greater part of the tree on each side of the stem is generally barren. This is caused by the trainer's dislike to long irregular spurs projecting from the horizontals, which destroy the snug regularity of the tree, to maintain which the knife is used at least twice in the year. Thus the strength of the tree is chiefly wasted in the production of numerous shoots, destined by this style of pruning and training to be cut away.

That this fashion of sacrificing the use of the tree to its artificial beauty is a very prevalent horticultural error, must be granted; but that both objects may be gained is not an impossible case; for it has

been proved by an eminent horticulturist * that the summer shoots may be so managed as to be formed into fruit-bearing spurs all over the tree. This system of pruning is chiefly applicable to the more choice sorts of trained apple and pear trees; and is detailed at great length in the Gardener's Magazine, vol. iii. p. 1, and in a treatise on the subject by the same experienced practitioner. The principle is, by stopping and shortening at different times a selected number of the summer shoots, the buds at their bases are prompted to become flower buds on every part of the tree.

Here we may again observe that the idea of a bud of a pear or apple tree requiring two or more years to raise it from the state of a leaf bud, to that of a flower bud, appears to be reasonable in the case to which we have just alluded. That there are exceptions to this as an invariable rule, has already been shown; but here it holds good in respect of those buds left at the base of the shortened shoots which, in a longer or shorter time, become fertile.

It has been presumed in our view of the structure of apple and pear trees in particular, that every bud contains an embryo flower on the summit of its axis, and that it only requires a certain exposure to full air and light, and a certain stationary repose, to mature its reproductive organisation. To illustrate this process of the development of a bud of a tree we

* Mr. Charles Harrison.

have already compared it to the bulb of a seedling tulip. The senior division of the latter, from the moment it assumes the form of a bulb is composed of a certain number of leaves which, in the space of a few years, are annually expanded, and the centrally placed flower at last comes forth ; so the former is first a leaf bud, and under favouring circumstances is ultimately a flower bud. If in its first stage it receive extraordinary excitement from the exuberant state of the tree, and before its fructiferous principle has had time to become mature, it is ejected forth as a summer shoot with the incipient flower on its apex ; but if, from its lateral position or other cause, it be arrested in its place, and expand only a few leaves in the first year, and a few more in the second, it is very probable that a bud so developing itself will be a perfect flower bud in the third year. The result of the method of pruning above adverted to, pretty clearly shows that the foregoing description of the progress of a leaf-bud to a flower-bud is sufficiently proved.

The different methods of pruning trained trees, adverted to above, are applicable to most of the common sorts, the fig excepted. This fruit tree, in its native climate, yields two crops every year, and upon two sets of shoots. The first shoots are produced in the spring, and ripen their fruit in the autumn. A second birth of shoots comes forth about Midsummer and perfects their fruit early in the following summer. But in this climate, although the tree grows in the same manner, yet the fruit on the spring shoots never

ripen in the open air, and the crop on the Midsummer shoots not till the autumn of the following year. The British gardener, therefore, must preserve the Midsummer shoots, and to assist their formation may stop the spring shoots in June in order to procure a full supply of young wood after that time. This tree, when skilfully managed, well repays the labour bestowed on it. It may be kept and forced in pots, and trained in any direction. It bears *ringing* and every kind of manipulation with impunity.

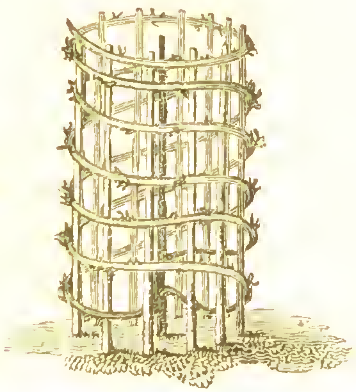
As severe pruning has been shown to predispose a fruit tree to produce barren growth rather than fruitfulness, it is necessary to be cautious in the use of the knife, when the object is the production of fruit. The grand desideratum is, after a tree has arrived at a fruit-bearing size, so to manage it as to induce moderate growth. As this cannot be accomplished by pruning, cultivators have had recourse to other expedients, viz. different modes of

Training.—It has already been observed, that the growth of trees is always most rapid in right lines, whether these be perpendicular, oblique, or horizontal from the root. The fluids progress with increased celerity in direct channels; consequently when the stem or branches are bent into tortuous or circuitous positions, a steadier flow is generated, and subdued action takes place promotive of fruitfulness. Besides the different methods of training already alluded to, gardeners have invented several very curious and successful modes, which are worthy of imitation.

Dwarfs and riders, the former to cover the lower, and the latter the upper part of the wall, are commonly planted. Both are trained in the fan manner; but this form is not indispensable to peaches, nectarines, &c., any more than to other kinds of fruit trees, for they may be led in any direction, and often with manifest advantage. Low walls may be covered by half riders, merely by training one half of the branches downwards, and the other upwards; that is, allowing the branches to diverge in all directions from the top of the stem.

For pear trees and the like, French gardeners adopt the method called *à buisson*, *i. e.* like a bush. This is formed by driving a row of stakes in a circle round, and at about eighteen inches distance from the stem of a young tree. The branches are brought to the outside of the stakes, and trained spirally round them in one direction, Fig. 60.

Fig. 60.



The advantages of this style are, the branches are allowed to run to a considerable length—they are supported against injury from wind—the whole tree is within easy reach, and occupies but little space on the borders of a garden.

Another plan is called *à quenouille,* i. e. like a distaff. In this the stem is trained erect, and the branches drooping; spreading to a diameter of four or five feet at the bottom, and tapering upwards into the form of a cone.

Fig. 61.

A rank of trees trained in this manner have a very dressy appearance, and as the branches do not overshade each other, is an advantage which the preceding has not: both are equally convenient and suitable for dwarf fruit-trees.

The object of this training is merely to counteract the aspiring and spreading tendencies of the trees,

and by so doing inducing moderate growth and fruitfulness.

It has been said of orchard fruit, particularly the apple. that they have only a temporary period of health and fruitfulness, and that after the meridian of their vigour and fertility, they become constitutionally so feeble, that they cannot be perpetuated by any method of propagation without conveying the decrepitude of the old to the young trees.

As all kinds, forest as well as fruit-trees, die of old age, it is perfectly reasonable to conclude, that any one of the latter, which are but varieties, and have endured the operation of grafting, pruning, and other manipulations, should be necessarily shorter lived than a natural tree of the forest; and also that their decay will commence sooner than such as rise from seed.

That grafts and buds carry along with them certain characteristics of the parent tree has been already shown: it is a fact of which there can be no doubt; and if such old apple trees produce no perfectly sound young shoots, it cannot be expected that healthy young trees can be reared from them. But, on the other hand, if the young shoots at the top of the old tree be perfectly sound, and free from visible decay, they are as well fitted to be the basis of a new tree as any other shoot produced at any former period of the parent's life.

It must be admitted, however, that during these last thirty or forty years, there has been real difficulty

in raising healthy trees of some of the old, esteemed sorts of apples. Whether this difficulty has arisen from a careless choice of grafts, or from the assumed cause above alluded to, we are not quite satisfied, because the failures have not been universal; and because we know, that if a young golden pippin, for instance, be planted in an old orchard or garden, it seldom thrives; whereas, if planted in fresh, newly trenched soil, it both grows and bears well. It is also well known, that though a great majority of the old golden pippin, golden rennet, and nonpareil trees have gone to decay in old orchards, there are in many places fine healthy trees of all ages growing vigorously; so that much of this failure of orchard-fruit may have proceeded from local or accidental causes.

An apple-tree, like all others, has a natural term of life. It stands till the interior of the trunk is dead and rotten, and then falls a prey to the wind: notwithstanding that the vitality on its exterior, though weakened, may be as essentially perfect as ever. It appears that the amiable Evelyn did much in his time towards advising the planting of orchards, as well as forests; and it is probable, that the orchards planted about that era, (1700,) are those which of late years have so suddenly gone to decay.

Planting and maintaining orchards has been always considered as a legitimate object in rural economy; and more or less attended to, according as the usage or taste of the rural population in articles of

diet, rendered orchard fruit necessary. In Hereford, and other western counties of England, orcharding is an important concern, because cider and perry are the common beverage of the people. This was also the case in most of the middle and eastern counties formerly; but in these, extensive orchards are gone to decay through sheer neglect, owing to the substitution of porter and other malt liquors instead of cider, and consequently making the cultivation of barley upon light land, (unfit for grazing purposes,) much more profitable than a crop of apples or pears. Added to this, the introduction of tea instead of milk diet among the lower orders, has not a little tended to discourage orcharding, (which were also pastures for milch cows,) and cause the neglect of those fruit-trees, which used to be depended on for the drink of the farmer and his family, and which are now said to be wearing out.

To the foregoing observations on pruning and training fruit-trees, a general remark may be added, viz.: as there are hardly two situations exactly alike in all things, the same rules will not always be applicable. Soil, aspect, climate, and particular varieties of fruit will require particular and local modes of management; and that practitioner, who has the most comprehensive views of the physiology of trees and their culture, and who can divest himself of old rules, (considered by too many as indispensable,) will have the best chance of succeeding in his practice. He will not be cramped by precedents, though recom-

mended by the first masters, nor confined by fixed rules in any of his operations ; but considering only the local circumstances which affect the objects of his care, will shape his manner of both pruning and training accordingly. The practice and opinions of intelligent practitioners alluded to in this section, are not so much brought forward for dictating rules, as to show the tractability of the physical members and evolutions of plants.

Flowering Shrub Pruning.—The object of the fruit-grower, and that of the florist, in pruning their respective plants, is nearly similar. The florist endeavours to gain either numbers, or magnitude of flowers. All sorts of trees and shrubs having terminal flowers, as *Magnòlia*, *Camèllia*, *Rhododendron*, &c., are made floriferous, by checking luxuriance of growth, which is accomplished by the means practised for dwarfing fruit-trees, viz., by grafting, budding, confining in small pots, limiting the supplies of water, or lowering the quality of the soil in which they are grown. Such as bear their flowers laterally, as the almond, myrtle, &c., should, by pruning, be made to produce numerous shoots, in order to have a full bloom. In general, however, our flowering shrubs, as well as trees, are left to nature ; little pruning being necessary except to keep them in form.

Of all flowering plants roses require most knife-work. It is indispensable to correct their straggling habit of growth, as well as to obtain perfect and abundant bloom. The flowers being borne on shoots

of the present year, which, when the flowering is over, remain of very irregular lengths, require to be annually cut back to the second or third bud at their base, which buds yield the flowers of the next year.

Tree roses are a lately introduced ornament of our shrubberies and lawns. The high estimation in which the rose is held, is always an excuse for the natural deformity of the tree; and the new form imposed, viz., a tuft of flowers and foliage on a tall, slender stem, supported by a stake, is any thing but graceful, unless they stand among evergreen shrubs. In this situation they are very striking, and when worked with different sorts, which flower at different seasons, very ornamental. Such should be always closely pruned in, not only to keep the head more compact, but to increase the number of the blossoms.

The flowering season of roses may be retarded or prolonged, either by late transplanting in the spring, or by double pruning, that is, when the shoots, after the first pruning, are about an inch long, to prune them off down to the next undeveloped bud below.—*Gard. Mag.*

The florist extends his pruning even to his herbaceous plants. The principal flowers of pinks, carnations, georginas, chrysanthemums, &c., are much enlarged by being divested of supernumerary stems, or of the secondary flower buds on the same stem.

This leads to remark here, that thinning flowers or fruit, operating so as to cause increased bulk of those that are left, shows that the current of nutri-

tion from the root may be diverted into any number of channels that skill may direct, either for the purpose of enlarging leaves, shoots, flowers, or fruit.

Table fruit-bearing herbs, as the melon and cucumber, require pruning; their fruit is borne on the tertiary, much more frequently than on the secondary or primary shoots; therefore the two latter are stopped at the proper time to cause the production of the former. The manipulation is, however, always governed by the state of the plants; those raised from old or much dried seed, often show fruit on the secondaries; thereby rendering the production of tertiary branchlets the less necessary.

CROSS IMPREGNATION.

One of the most important advantages which has arisen from the discovery of the sexes of plants, is the practicability of improving both flowers and fruit by what is called cross impregnation. By this means we find that plants are susceptible or partaking of each other's forms, colours, and qualities, thereby allowing the combination of excellencies obtainable in no other way.

When we contemplate what has been accomplished in the amelioration of our native fruits, or consider how much our culinary vegetables have been improved, we can attribute these beneficial results to nothing else than this susceptibility of vegetables receiving sexual impressions from each other.

In former times and before the study of plants had become a science, many improvements had taken place by accident. The improved sort, whether a new variety of a flower or fruit, had a conspicuous station in the collection of the orchardist or in the bed of the florist. Its qualities were imperceptibly distributed around among its congeners by no other agent than the unconscious bee flitting from flower to flower, or by the less certain instrumentality of

the passing breeze. In time, however, botanical physiologists, investigating the powers and principles of vegetation, and seeing that the male matter or pollen of plants was a deciduous and transferable body, conceived the idea of obtaining by manipulation, what had before been only adventitiously accomplished by the bee and the breeze.

Conveying the male to the female plants of the Linnean class *Diœcia*, and the male to the female flowers of the class *Monœcia* is an old practice ; but that of transferring the pollen of hermaphrodite flowers from one to another is a modern invention. Whoever was the first practitioner of this ingenious art is not, perhaps, exactly known ; but every body in the horticultural world is aware of the valuable results which have followed the judicious experiments of A. T. Knight, Esq. president of the Horticultural Society of London. That gentleman, by the skilful transference of the pollen of one fruit tree to another, has produced some excellent sub-varieties of fruits which are estimable acquisitions to the dessert. His example and writings on the subject, have extended the powers and practice of the florist as well as the fruit grower ; valuable consequences have already taken place ; and a boundless field is opened to the cultivator for farther improvement in every branch of gardening.

The impregnation of the ovulæ of one plant by the pollen of another, is a phenomenon which cannot be illustrated in any other way than by comparing it

with similar phenomena happening in the animal kingdom. In the latter it is only nearly allied species which hybridise. The *mule* and *hinno* are hybridal varieties of the horse and ass; but of this there are but few exactly similar examples among plants. Among the latter, family affinities only can be affected by the pollen of each other. Attempts have been made to show that many of our species are only amalgamations of others; and that all intermediate species between the first and the last of a genus, are only adventitious creations; yea more, that the varied vegetable kingdom originated from a few *Fuci* that first sprung up in the waters, and afterwards spread over the face of the earth. But this view is wholly visionary; being applicable to varieties of plants only, not to species.

Animal hybrids have a peculiar characteristic, viz. that though the progeny from the cross partake of the form and muscular powers of both sire and dam, they, with very few exceptions, are denied the power of reproduction. Real hybrids have been raised between two species of *Verbàscum* many years ago by Mr. Haworth, and lately between two species of *Digitàlis* by professor Henslow aud Mr. Denson. The hybrids of *Digitàlis* were barren, and in this resembled those of animals, but among varieties of species, some of which, from the monstrous fulness of the flower, are indeed sterile, yet in general they are prolific, and consequently capable not only of perpetuating themselves, but of being multiplied into

sub-varieties without end. It is amongst this last description of plants that the art of cross impregnation promises to be so useful an auxiliary in the business of the fruit and kitchen gardener.

The manœuvre generally succeeds under the following circumstances: the two plants whose properties are sought to be combined, must be nearly allied *varieties of the same family or genus*, as apples with apples; cherries with cherries; roses with roses; pinks with pinks, &c. There must be a verisimilitude of structure; and of the qualities of the juices respectively. The pollen must be perfectly ripe when used, and the stigma to which it is carried must also be in its fully mature state. In order that the impregnation may take place and be complete, it is the custom of some florists to deprive the flower operated on of its own stamina, to shade and shelter it if necessary, and by displacing rival flowers near it, give every chance and encouragement to the impregnated flower to ripen its seeds.

If a new and valuable variety of fruit be thus obtained, we must admit that the change originates in, and is conveyed by, the impregnated seed. Hence a question arises, will the seeds of this improved variety continue the improvement, or do they after the first generation go back to their originals? This question has not yet, perhaps, received an answer from experience; but if answered negatively, then we conclude that it is not only like other improved fruit trees in this respect, but also, that it is the impreg-

nated seeds *only* that convey the change. In adverting to this circumstance in another place we have supposed that the floral and other members of a plant may be changed or improved without the seed itself being affected. But in the case we are now considering, it is evident that some of the seeds are affected by the strange pollen, because the seedlings raised therefrom present the improvement. On this subject we need more information ; for it is not easily understood why varieties of herbs, as cauliflowers for instance, as before observed, should perpetuate themselves by seeds, and not those of fruit trees, as the apple and the orange.

The practicability of cross-impregnation has alarmed scientific botanists ; they fear that their classifications will be thereby broken down into a chaos of nondescription, in which all specific and even generic distinction will in time be so amalgamated that identification will be impossible ! Without partaking of these fears it is but right, however, to declare, that as it can serve no purpose of the mere botanist, the practice of impregnation should be confined entirely to the business of the commercial and amateur florist, the kitchen gardener, and more especially the fruit-grower.

When we look at the varieties of the *Hyacìnthus orientàlis* and the *Tulìpa gesnerìana ;* or when we consider (what is of much more solid advantage to mankind) the improvement of the austere crab and sloe, the worthless gooseberry and strawberry in their

native woods, and, moreover, the wild cabbage on our shores, we must admit the great importance of cross impregnation, as one of the means which has brought about such signal triumphs of cultivation as are exemplified in the improved varieties of these several plants. But, besides these, we may instance the beautiful varieties of cherries from the wild guigne; the peach and nectarine, probably from the almond; and, in warmer climates, the almost countless numbers of the citron family, from the uncultivated lime. What has been already accomplished is invaluable, and is an earnest of how much more may be done by similar means.

Among our cultivated fruits many are regarded for peculiar qualities of high flavour, long keeping, or as abundant bearers. These properties of one variety may be transferred to others where they are wanting. A good bearer of inferior quality may be improved by being dusted with the pollen of a high flavoured sort. The union of a ribstone pippin with a hawthorndean, for instance, would be an improvement. That between the whiteheart and bigaroon cherries would be a desirable variety; and so of many others.

Among flowers, the prospect opened by the practice of cross-impregnation between varieties is boundless! Where splendid colours are required to be added to elegant forms; where variegation would improve a one-tinted blossom, or where the rich colours of a dwarf are sought to be given to a flower of more ample habit, all this is in the power of the

skilful hybridiser. All bulbous stemmed, and other herbaceous flowering plants, as well as shrubs and trees, are susceptible of such mutations.

Even the ingenious farmer, who may be acquainted with this transmutable property of plants, may benefit himself and his country by creating new varieties of corn. Our best known kind of barley for the purpose of malting, indeed for all purposes, is only a variety, and, what is more, a deformed and imperfect sort, inasmuch as two sides of the spike are always abortive; yet this is preferred to all others. Among the varieties of wheat, some have short ears, but with superior grain as to quality; others with very long spikes of inferior grain. A union of these is fairly within the bounds of possibility; indeed it is more than probable that superior varieties of all our corn may be obtained by cross-impregnation judiciously executed. But enough has been said to direct attention to this curious subject, it being unnecessary to point to particulars, which will readily occur to every one engaged in, or the least acquainted with, the cultivation of plants.

There is a circumstance connected with manual impregnation which may just be mentioned; it has been observed that strange pollen, that is, such as is taken from other congenial trees, is more effectual in its operation to secure the production of seed than that of the plant itself. The filbert and cob-nut are said to bear more profusely if assisted by having a branch of the common hazel, well furnished with

catkins, suspended over the former trees at the proper season. Whether this effect, supposing it true, be owing to the proper male flowers being expended too soon, or from the incontinent appetite of the females, is uncertain. Be this as it may, the phenomenon is, however, very similar to what is often seen to take place among breeding animals.

Another advantage arises from cross-impregnation, namely, making fine flowering exotics that are too tender to bear the open air in Britain, more hardy. If the tender female be dusted with the pollen of a hardy male of the same genus, or *vice versâ*, a variety will be produced which will possess the beauty of the one in a great degree, and the hardihood of the other; and by advancing to gain hardiness in one direction, fine colour may be obtained by trying back. If acclimatation be at all a practicable expedient, cross-impregnation appears, from what has already been accomplished, to be one of the most effectual means. This opinion is founded on what has lately been accomplished in crossing the *Rhododèndrum arbòreum* with the *R. pónticum;* an intermediate variety has been obtained, partaking of the colours of each somewhat blended, together with a great portion of the hardiness of the *R. pónticum*. As species have only a limited range of constitutional variation, we know not how far such changes may be carried; but even this union between two reputed and distinct species shows that our knowledge of the powers of plants is not yet complete.

VEGETABLE FOOD.

WHAT is the food of plants? has always been an interesting question among cultivators. The chemical philosopher says—ascertain by careful analysis the qualities of their components, and you may safely infer that similar bodies or qualities must necessarily be their food.

This doctrine, however, notwithstanding its plausibility, has not been fully proved by experience. Vegetables are so organised that they are not only capable of imbibing various fluids from the earth and air, but also can assimilate them to their own essential qualities. From the same situation and soil, different plants extract different principles. The *Saccharum officinalis* and the *Janipha manihot* grow on the same spot; the first elaborates the most agreeable and nutritious juice; the second a most dangerous poison!

But, perhaps, the philosopher only alludes to the elements of plants, such as oxygen, hydrogen and carbon, and not to their elaborated qualities. If so, it may be observed, that all these exist universally in the air and water, consequently more or less in

every kind of soil; so that were it possible to collect them in such a shape as to be tangible and distributable the attempt would be superfluous; except only as regards carbon, which, as it exists in the excrement of animals, is a powerful assistant to vegetation wherever obtained and used.

But by far the greater part of our knowledge relative to the food of plants, has been derived from experience. Chemistry, with all its powers of analysation, &c., has hitherto done but little, and that little seldom attended to as it deserves, especially in the management of farm and stable yard dung, and composition of mixings or composts. Every cultivator is aware that all recent or decomposed vegetable matter is a useful pabulum of living plants; as well as all animal substances whether recent or rotten. Farm-yard, fold, and stable dung, wood ashes, bone dust, and horn shavings; the refuse and sweepings of butchers', curriers', and fellmongers' yards and workshops; linseed and rape seed cake; woollen, linen, silk, and cotton rags: in short the offal of every employment, where either animal or vegetable substances are manufactured—are all found valuable manures.

Mineral substances, as salt, lime, chalk, marl, coal, culm, soot, and ashes, are all used on land as direct or indirect stimulants thereto. These combined with some of the components of the staple, promote it is said the solution of effete matter, and prepare it for the sustentation of plants.

When the texture or constitution of the soil requires amelioration, other expedients are had recourse to besides adding to its fertility. The best soils are composed of nearly equal portions of sand and clay, together with the detritus of calcareous rocks, and decayed vegetable or alluvial matter, generally called loam. Its consistence is friable; readily admitting air and rain, and as readily discharging all excess of the latter—only retaining, or imbibing from the air, as much as is suitable to vegetation: and neither liable to be parched in summer, nor drenched with surface water in winter.

If a cultivator be situated on a soil which is different from the above, his main endeavour is to improve, by bringing his land as near to this standard as he has means or opportunity to accomplish. Covering his sand with clay or marl, or his clay with sand, is the most direct, though a most expensive mode, and which but few can undertake except on a small scale; yet when these two descriptions of soil lie contiguous, the union may be performed gradually, and a garden or a farm may be completed in no great length of time.

Such improvement of the staple of land, with periodical dressings of good manure, would amend and render it capable of bearing any kind of crop; and moreover facilitate all operations necessary to be performed upon it ever after.

Lime is much used as a quickener of the soil, and for the purpose of banishing insects, and particularly

the slug. Both lime and chalk are excellent applications on clayey soil for counteracting its adhesiveness; because, as both are powerful absorbents of water, the frost acts with redoubled force in disrupting the compact surface of the clay—rendering ploughing and harrowing easy. Both these substances, as well as common salt, are also used on dry gravelly land; they being attractive of moisture in all seasons, and consequently highly serviceable to summer crops. It is only when lime is in its caustic state it is prejudicial to slugs; after being slaked and saturated with moisture it only acts in the manner of chalk. Some kinds of lime-stone contain magnesia; which last substance has been found deleterious to vegetation in its caustic state: and therefore only fit to be used on peaty soils.

All fresh or newly broken up ground contains some peculiar quality particularly acceptable to plants, especially such as have never, or not for a long period before, been cultivated thereon. Such soil is called maiden or untried; and unless decidedly sterile, by reason of wanting a sufficient depth of surface mould, or strongly impregnated with metallic principles, will yield abundant crops successively for several years. From this circumstance it would appear not only that vegetable food exists in soils which have never been enriched by the cultivator, but that it is also exhaustible. Hence the necessity of applying manure to keep land in heart, and to enable it to yield remunerating crops.

Maiden earth has not been investigated by the chemist so thoroughly as it should be. They have attended more to the analysis of what are supposed to be manures, than to those qualities of natural soils which are so eminently salubrious to vegetation. We are still ignorant whether this quality be a chemical or physical body; or whether some latent principle set at liberty or brought into action by the plough or spade. Certain it is, however, that the first crops on newly broken up land are always superior to those that follow, and when a garden soil becomes "worn out," as it is called, it can only be renewed by removing the old, and replacing it with an equal quantity of fresh earth from a common or old pasture.

As a mixture or change of plants on the same spot arrive at greater perfection than if one sort only were sown by itself, or repeatedly sown or planted on the same place, it has been reasonably supposed, that different plants require different kinds of food*. On this supposition the system of what is called "convertible husbandry" and the different courses of cropping adopted by agriculturists are founded; and the uniform success attending such procedure is sufficient proof of its propriety. Hence the value, and necessity of composts being formed of every kind

* It is believed by some botanists that every plant has the power of disgorging matters which are hurtful to the system, by which the soil becomes unfit for others of the same kind.

of vegetable and animal matter that can be collected and incorporated together, in order that the crop, whatever it may be, may have the power of selection.

The luxuriance or weight of a crop is always in proportion to the richness of the soil, or to the quantity of manure bestowed, other circumstances being favourable ; but it is usually apportioned to the nature of the crop intended to be raised. If bulk of stem, leaves, or roots, is the object, it is scarcely possible to give too much ; but if for superior grain or fruit, moderate quantities answer best.

In whatever way manure be applied, whether by incorporating it with the soil, or diluted in water, the effect on the plant is the same ; every part, viz.—root, stem, leaves, flower, and fruit, are enlarged, showing that either the vegetative vigour receives extraordinary excitement, or that the juices become more copious, so that their power of distension is increased. Stronger and accelerated growth is the effect, and no doubt caused by the additional supplies of aqueous and gaseous elemental bodies essential to the plant which are afforded by the manure ; but whether these supplies be carbon only, or a combination of various chemical principles collected by the spongioles, and so imbibed together, we have yet to learn. One thing is very certain, that all substances used as manure, are more or less effectual according as they are more or less attractive, and retentive of humidity.

Respecting the effects of fallowing, it is quite evi-

dent from experience, that it is only necessary and useful for two purposes. The first is the destruction of weeds, the second the amelioration of the soil. After a course of four or five crops, which have been only partially, or not at all weeded, root-weeds, particularly quitch, thistles, docks, and several others, get possession of the soil, and render it impossible to extirpate them without a summer fallow. On the other hand, if land be of a strong, clayey, adhesive nature, fallowing is absolutely necessary to prepare it for the reception of seed. As to the idea that land is benefited by exposure to the sun and air, except for the purposes of desiccation and more perfect comminution, no greater error was ever conceived; because it is well known, that the nutritive qualities of the soil are fugitive under the action of the sun and air. Laying light land into ridges, either by the plough or spade, to receive a winter's frost, is, therefore, not only a waste of labour, but of some of the best principles of the soil.

Deep trenching, digging, or ploughing, is beneficial to trees and all plants of robust character, not only because it allows a greater range for the roots, but also because it permits the ascent of warm and humid vapours from the bowels of the earth. When the staple of land is once well broken up for corn, deep ploughing is not so necessary afterwards.

The effects of different soils on the quality of vegetable productions may just be noticed. Fruit or vegetables raised on a light sandy loam, having a

gravelly subsoil, are always found of better quality than such as are produced on rich heavy land. That is, the fruit, though smaller, contains more sugar; and the kitchen vegetables, though more diminutive in bulk, are of better flavour. The concentrated juices in both these cases, and farina of cereal plants, are greatly superior to the productions from off deep, rich, or highly manured land. Grossly exuberant crops are always more crude in the quality of their sap, as well as coarse in cellular structure. These circumstances should not be forgotten in forming fruit borders; mistakes are often committed in making them too rich, as well as too deep; hence the trees grow too luxuriantly, and yield large-sized fruit; but the flavour is inferior. Fresh unexhausted loam, provided it be dry enough, is the best for all kinds of fruit-trees; and this last particular can only be ensured by efficient drainage.

DISEASES OF VEGETABLES.

That plants are subject to disease is generally admitted, though it is often difficult to distinguish constitutional distempers from the attack of insects or of parasitical plants. The canker, mildew, uredo, smut, ergot, are all prevalent; and all other disorders, whatever may be their cause or origin, are comprehended under the common name *Blight*.

Canker appears to be really a constitutional disease. It is a dismemberment and corruption of the organisation, occasioned, it is supposed, by unwholesome aliment, taken up by the root from ferruginous soils, and which, when lodged in the tender vessels of the young shoots, undergoes some chemical change destructive of the vital envelope and all the other members of the plant.

It first shows itself in small blisters on the epidermis of the young shoots, or round the buds, and at the base of the spurs on the older branches. The taint quickly spreads, corroding every organ in its course. The parts affected become suberous, fractured and monstrous, and are chosen as a nidus by several species of insects, whose larvæ feeding on the lips of

the sore, prevent the efforts of nature to heal it up, till at last the branch on which it appears is destroyed. Partial attacks are sometimes cured by cutting away the diseased parts and applying plasters of grafting wax, or of cow-dung, clay, and urine.

That the taint of canker spreads from its first visible station, is very apparent to the operator when cutting out the infected part. The principal sap vessels are tinged with a brown unhealthy colour for a considerable distance from the first seat of the disease; all which contaminated organs must be cut away before a cure can be effected.

Canker is more frequently seen on orchard fruit trees than on others. Among forest trees the ash and elm suffer most. It is invariably found, that the most luxuriant growing trees are more subject to the attack than such as are of moderate growth; and those on dry sound situations, less liable than such as stand in wet soils where the drainage is imperfect. Low sheltered situations, where there is not a free and constant ventilation, also appear to invite this disease.

This being the history of the distemper, it is quite obvious that no topical application can be effectual as a cure. If the poison be taken in by the root, from pernicious qualities in the soil, or if generated by unwholesome air, these circumstances must be changed before the attack of canker can be averted. Shallow planting, perfect drainage, and the application

of proper manures to neutralise the injurious qualities predominant in the soil, are the most eligible means to be followed to preserve trees from its ravages.

Canker also appears on some sorts of herbs. Blanched celery, endive, and lettuce, are all subject to be disfigured and spoiled by something like canker. The curl on the leaves and the scabs on the tubers of the potato, are deemed to be diseases of the same kind. So is that on the cucumber and melon; but on these last the cause is well known, namely, a want of sufficient heat in conjunction with too much humidity. Some of the former may be the work of invisible insects, *fungi*, &c., and others, as the brown spots on celery and the curl on potatoes, appear to be endemial, as they are only known in certain districts for a year or two, and then disappear. Our reason for averring this much is founded on the history of the disease, and on what we have gleaned from experience. At one time the curl was very prevalent in the south of England, now it is rarely and only partially seen. Some writers attribute the disease to the use of over ripe tubers as sets. Many cultivators in the Lowlands of Scotland prefer potatoes for sets, grown on cold moor earthy districts in the Highlands. In Wales it is said to be an insect; but in most of the central counties of England, as it is seldom seen, no precautions are taken to prevent it, except occasionally changing the kind, or procuring sets from a distant place; and this not to prevent curl, but to obtain better crops. From many published reports

it would appear that the defect exists in the eye before its sprouting, because how else can we account for one eye only (the one nearest the umbilical cord) being generally, if any at all are, curled, and no other. Whether it be an insect or a disease we have still to learn.

In all these cases we find the cellular organisation imperfect and decomposed, and soon afterwards the resort of insects or the seat of *fungi*. There can be no doubt but that canker is sometimes caused by the attack of insects, by injudicious pruning, or by accidental wounds; but it is equally certain that it appears spontaneously, as if generated by some deleterious quality received either from the soil or situation.

It is more than probable that canker is transferable from one tree to another by intergrafting; we very often see maiden plants attacked by it before they are removed from the nursery; and though this is generally attributed to the presence of an insect, it is as likely to have been introduced on the graft.

There is a fungus known among naturalists called *Æcīdium lacerātum*, which fixes itself on the bark of the whitethorn and pear trees, occasioning cankerous spots, and consequently pernicious to the plants. It is, however, endemial, and often mistaken for canker.

Mildew—infests many kinds of plants and assumes many different appearances. On peach and nectarine trees, it seizes the tender points of the shoots, which it quickly destroys. On the leaves of the apricot,

cucumber, &c., it shows itself in spots, and in dry seasons it is almost always seen on the leaves of early turnips, and late sown peas in the autumn. It has been ascertained by naturalists that mildew is a species of fungus which attaches itself to certain plants when they are in a peculiar state of growth favourable to its nature. If this be so, it cannot with propriety be called a disease, though its effects are equally destructive. Luckily it is a vegetable parasite of a more delicate constitution than are the plants it fixes on, because it very soon yields to an application or two of a strong soap lather or a lixivium of flour of brimstone and water. By these means it is easily banished from trees in houses, or on walls. And there is no doubt but that water slightly impregnated with soda, or any alkaline salt, used as a wash, would defend plants from its attack, as well as recover those already suffering from it. Its appearance on turnips, and particularly on peas, is said to be a consequence of drought; and that if the latter crop be well watered when necessary, the mildew is prevented.

Uredo or rust.—This is a malady, or rather an injury, to which cereal plants, wheat in particular, are often liable. This, like the mildew, is also a fungus, which seizes on the leaves and straw in such numbers as to interrupt the course, or withdraw the whole current of the sap. Hence the grain is imperfectly filled, the colour and tenacity of the straw is destroyed, and the crop, of course, generally deteriorated.

Rust first appears on the leaves of strong growing

plants of wheat early in May, but it is not seen to fix injuriously on the culms till about the 20th of July. Should the weather at this last mentioned date be dry, and at a high temperature, no ill effects from rust take place ; but should wet weather then set in, chilling the air, and checking the exhalations from the ground, immediately the straw is struck, and suddenly changes from a bright yellow to a dingy hue, a certain sign that the blight, as it is commonly called, has seized the crop. About this time the grain is just arriving at perfection ; if the attack takes place before this is effected, it never fills ; if afterwards, less damage is sustained ; the straw may be injured but not the grain. In looking over a blighted field of wheat we observe that the lowest and richest stations, or where the crop is thin on the ground, receive the pestilence more severely than the higher situated, or poor portions of the field. In some seasons the crop is only partially, or locally affected ; in others not a culm escapes.

These circumstances prove that the evil is always commensurate with the susceptibility of the plant to receive it, and to that critical state of the atmosphere which favours the vegetation of the fungi.

Some writers have imagined the *Pucinia graminis* (the name now given to this fungus by botanists) is the effect, not the cause of the malady. The evil, say they, proceeds from exuberant growth, and a surcharged state of the sap vessels, which first rupture the cuticle, whence the sap flows out, forming an

attractive and suitable seed-bed for the *fungi;* and, therefore, advise the farmer to dress his ground moderately to save his crop. Were the diminutive or stunted plants never assailed by the rust, then the above opinion may have some weight, and the advice some value; but in a blighting year, every wheat plant, from the smallest to the largest, suffers; showing that it is an atmospheric influence that predisposes the plants to suffer, and the fungus to luxuriate. The *propagines* or seeds of the fungus are impalpable and invisible; and being carried by the wind from place to place, settle on every object, but come to perfection only on such plants as are in a suitable condition to receive them.

The same species of fungus* or one nearly allied to it, is frequently seen on the common berberry, coltsfoot, and some other plants. Hence old fashioned farmers *eradicate the berberry* from their hedges. A laugh has been raised at this practice, but there is more propriety in it than superficial observers are disposed to allow. As the ovæ float in the air there are no means of averting the attack. Early and thick sowing on sound and well drained ground, is the only practicable preventive.

Smut.—This is a disease peculiar to cereal plants.

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* It has been lately ascertained by J. Rennie, Esq. professor of natural history in King's College, London, that the parasite fungus on wheat is a distinct species, and not the same as that which attacks the berberry and some other plants. This is confirmed by recent discoveries of other naturalists.

Its history is obscure; it not being ascertained whether it be the work of an insect or the seizure of a parasite. The husk of the grain, instead of containing healthy farina, is filled with a black stinking powder, rendering the grain unfit for the baker, and often unsaleable. It is not a radical distemper, else all culms and ears from the same seed would be equally affected, which is seldom the case; plants, and even the same ears, are only partially smutted, which would not happen did the defect originate in the root. The disease exhibits itself in two ways; in one, the husk bursts and the black powder is mostly dispersed by the wind and rain; in the other the husk remains entire, is cut, carried, and threshed with the bulk, and from which it cannot be separated except by washing in water to float the smut-balls. In this latter state it is dreaded by the farmer, as its presence greatly deteriorates the value of the crop. As a prevention against smut, farmers endeavour to banish it by brining and liming the seed. This is partly, though not entirely, effectual; but how it operates is unknown. Those who imagine the evil to be a fungus, say the pickling frees the seed from infection; while others, deeming it an insect, believe the ovæ to be destroyed by the salt and quick lime.

Ergot.—This is a disease of the same nature as smut. It is prevalent in rye, and is a great drawback on its value, in places on the continent where this grain is cultivated for bread-corn. Farmers in the south of France attribute its prevalence to a certain

moist state of the air at seed-time. An acute observer in this country thinks it is sometimes occasioned by late frosts, which occasionally affect the plants so as to cause this malformation of the grain. The general opinion is, however, that it is really a fungus, which, seating itself within the husk, changes the meal into grey powder. Several others of the *Gramineæ* are subject to ergot. The *Lòlium perènne, Festùca hordeifòrmis*, and *Elymus maritima*, are frequently seen disfigured by it; on the *Lòlium* it is black, and on the *Elymus*, red.

Constriction of the Bark.—This is a defect in the growth of trees, occasioned by the diminished powers of the root, or from the desiccating effects of dry or cold air on the branches. It has been already observed, that the bark is an excrementitious part of the plant. Nature intends, that as a new bark is every year formed next the wood, the outer or first formed layers should either be gradually thrown off, as in *Plàtanus*, stretched horizontally, as in the beech, or rifted longitudinally, as in the oak, to make room for the new accretion within. If, however, from any cause the outer bark becomes unnaturally indurated, so as to lose its expansive property, the internal growth is confined, and all the functions of the tree are paralised. Hence it remains stationary, the prey of insects, moss, lichen, and rarely fruitful; in which state it is said to be *hidebound*.

The old remedy for this defect was scoring the stem and branches from top to bottom quite through

the bark with the point of a pruning knife, in two or three places. This, if performed about Midsummer, evidently relieves the tree, as its future growth is much increased. The result is perfectly natural; if the envelope has its expansive action cramped, it will every summer struggle for a vent; and when the constricting bark is separated, the envelope will immediately be increased in volume, and a new impetus given to the secretions of the tree.

To such length has this remedy been applied, that the whole outer bark has been, by some arboriculturists, removed, to the manifest advantage of the tree. Indeed the same practitioners maintain, that the general barrenness and failure of old apple and pear orchards, is chiefly to be attributed to constriction of the bark; and the only way to renovate these, or other old trees, is to strip them of their old hardened covering *. It is said that cork-trees are invigorated by the loss of their bark, and that the same trees are stripped periodically without detriment to their health or natural magnitude.

Attending to the rationale of this practice, it is true, as has been before shown, that only a few of the recently formed layers of inner bark are absolutely necessary to the vital processes of the system. All those on the exterior are dead, and may be removed

* It should be observed here, that if fruit-trees be sound at the heart, and stunted or stationary in growth, they may be assisted by disbarking; but it is impossible to renovate old hollow trees much by such means.

without injury. If the whole bark be intended for defence of the stem only, and on this account preserved, it appears to be superfluous, because the young shoots, the most delicate parts of the tree, have only *one* bark, and this we see is a sufficient protection to all hardy trees; therefore all the layers are not necessary, as is proved by the remedy above mentioned being effectual. It is the opinion of some practical men, that the chief energy or vital vigour resides in the head rather than in the root of a tree, i. e., the head receives from the atmosphere a maturing influence which alone qualifies, while it excites supplies from the earth. The roots, if in good soil, however old, never fail; and, therefore, they say, if the head be kept healthy, the system flourishes. To do this, they recommend every feeble or dead shoot to be cut off, and every layer of the old scabrous bark to be periodically removed; so that every latent principle of the growth be called into action, and the progressive expansion of the tree encouraged. This doctrine, with some qualification, we think, is not injudicious.

Pear, apple, and other fruit-trees, are the proper objects for this treatment. Such as have a watery, being fitter for the operation than those having a gummy or resinous sap.

INSECTS DESTRUCTIVE TO PLANTS.

Although it be impossible to particularise every species of insect which breed and prey on plants, a few of the more common and noxious may be mentioned, in order to show how the health of plants is injured, and their members distorted or destroyed by their depredations.

Coccus.—This tribe of insects, of which the highly-prized cochineal of commerce is the type, are found infesting plants in hot-houses, as well as several of our most useful fruit-trees cultivated in the open air. The migratory white one, frequently seen on pine-apple plants, is highly injurious by withdrawing the juices and disfiguring the leaves, and still more when they fix themselves on the bottom of the stem among the roots. Both sexes are very minute when young; but the females, after impregnation, grow to nearly a line in length, are then very sluggish, and probably die soon after they have produced their young.

The next species is the well-known brown scale, so frequently seen on orange myrtle, and other plants, whose leaves are of a firm texture. In early life they are wanderers and invisible to the naked eye: but like the preceding, the females, after impregnation,

become stationary and large, by forming a shield over their bodies, under which they bring forth and rear their numerous progeny. It has been questioned, whether the scale, from under which the young ones come forth, be or be not a part of the body of the mother. If raised from the leaf by the point of a knife, there appear to be six legs, or tentacula spread out, three on each side, of a whitish colour, partly attached to the shell, and also to the leaf; but may not this covering be formed of an exudation from their bodies, by which their young are protected?

Another but much larger scale coccus is occasionally found in hot-houses, on peach trees, and vines. This is, perhaps, what is called the vine-fretter. Their economy is like the last, only with this difference, that as their young increase in size, the lower edge of the shield is raised up, and the progeny are suspended in a white silky web as large as a middling pea, from which they issue forth when able to provide for themselves.

Besides these cocci common in gardens, two others are found in woods and hedges, one of which, coccus arborea, has lately found its way into gardens, seating itself on pear and apple trees, which it weakens considerably. In underwoods they attach themselves to the bark of red willow and ash-poles, closely congregated together on the lower part of the stems. One of these has oval, the other kidney-shaped scales, or dorsal shields, about two-thirds of a line in length.

Their injury to these forest-trees is, however, imperceptible.

But the most destructive coccus in this country is what is called the American blight, or mealy aphis. This is the great pest of our apple orchards, and to the same kind of trees in nurseries. The young are so exceedingly minute, that they can, apparently, enter the pores of the epidermis, cause a swelling of the cuticle, which soon after bursts. The insects then may be seen in the openings, covered with a white efflorescence ejected from their bodies, intended it would seem, either for the purpose of concealment, or as a protection, instead of the scales with which their less destructive congeners are provided.

As this species seems to prey on the juices which flow between the bark and wood, or on the tender substance of the envelope itself, the former year's wood becomes denuded, and the lacerated edges of the wound become corky and monstrous, increasing in size till it encircles the branch, when all communication with the roots is cut off; of course the branch, or if the insects have seized the stem, the whole head, dies. Their manner of living and breeding is similar to that of the others mentioned above; the females attain the size of linseed nearly, and are constantly enveloped in the white covering peculiar to them, and by the buoyancy of which, it is said, they are wafted from tree to tree. They fix on the roots as well as on the branches of trees, and thus out of sight are often extensively injurious. The male is said to be a small black fly. The blood of these insects, if such it may

be called, is always of a deep, lurid red, showing their affinity to the cochineal insect, indigenous to the *Opuntia cochinilifera* in South America.

It has been stated that this coccus is the sole cause of the disease called canker; but this is a mistake, because cankered trees, both those of the orchard and forest, are every where seen unaccompanied by this or any similar insect. It is very true, however, that the dismemberment and distortions of the bark caused by either constitutional or accidental canker, are very likely to attract insects to nestle in, and this coccus as well as others; but the effects of constitutional canker may always be distinguished from those occasioned by the insect in question. It has also been said that the American blight was introduced about 1788 from France by the late Captain S. Swinton, R. N., who had a foreign nursery at that time, behind No. 6, Sloane Street, Chelsea. But however, true this may be, there is no doubt the same insect was in England long before that period; as old crab trees standing in woods and hedges in the middle counties were then, as now, covered with it. An insect of the same family is frequently seen on the underground stems of lettuce, endive, and dandelion.

Of all these insects, the mealy one infesting pines, and the last described so pernicious in orchards, are the most destructive; they both prey on the vitals of the plant, and their introduction among such as are clean should be carefully guarded against. The first are killed or banished by a wash composed of the

following ingredients, viz.; "2 lbs. soft soap, 2 lbs. flour of sulphur, 1 lb. leaf tobacco, 2 oz. nux vomica, and 1 quart train-oil all boiled together in 8 gallons of water. Pine plants require to be anointed all over with the liquor, and when re-potted in fresh soil and in a well cleansed house, are freed from the pest."—*Nicol.*

The same wash may be effectual for destroying the American blight, provided all the scabrous bark of the tree be first cut away, and particularly the little nodes raised by the insects, so that the liquor may penetrate into every crevice where the insects are secreted. A wash of the consistence of paint, of clay and water, soft soap and quick lime, mixed together applied with a brush is also beneficial to rid trees of this or any other insects.

Aphides.—This is one of the most numerous tribes of insects which infest plants. There are several species of them, as the *ulmi, sambuci, tilia,* &c.; but it is probable, that the same species assume different colours according to the qualities of the juices on which they live. The green aphis on the rose tree, the black one on the field bean, and the red one on the common tansy, are, perhaps, the same insect. They have many provincial names; as shrimps, blacks, lice, colliers, &c., the most common being the "green fly."

Being produced by animalcular generation, their fecundity is astonishing. On trees they blister and deform the foliage, disfiguring it by the emission of what is called honey-dew, so attractive to bees and

other insects. If they are favoured by dry and fine weather about the end of June they will seize the tender tops of field peas in such numbers, that the crop vanishes before them as if scorched by fire; and when the podless straw is cleared off, the ground is literally covered with their dead and dying remains, together with the sloughs they throw off during their short life. For such visitations there is no remedy; but in gardens whether they breed on plants in or out of doors, they are quickly dispersed by the smoke of tobacco.

Cynips or Gallfly.—These insects may be noticed not so much for the damage they do the plants on which they breed, as for the curious transformations produced on the members of the plant charged with their ova. If we examine the large imbricated galls on the extremities of the shoots of the oak, or the large and small globular galls called oak-apples, on the under side of the leaves, we cannot but admire the instinctive sagacity of the parent fly, and the curious expansion of the cuticle, the enlargement of the parenchymous integument under it, and the persisting functions of the sap vessels to supply a monstrous dilatation of all the parts immediately surrounding the inserted egg. As this soon becomes a maggot, daily advancing in size, so is the gall in bulk till the chrysalis is formed; soon after which, the last transformation takes place; the perfect insect eats its way through its parenchymous cradle, and launches into the open air. The perfect rotundity

of these galls and the pulpy consistence of their substance, in which the astringent quality and colouring property of the tree are notably concentrated, are interesting circumstances; showing that the unconscious nymph not only obstructs the direct current of the sap, but seems from its operations on the interior of the cavity to give form and consistence to the exterior, altogether different from the other expansive processes of the plant. From this incidental production, the physiologist may remark the wonderful versatility of the cellular body when disposed as parenchyma, and of its other structure in the shape of hybernacula when affected by the insertion of an egg of the *Cỳnips quèrcus-gèmmæ*. This insect, it appears, has the power of introducing its ovipositor into the very centre of the bud; there the egg obstructs the elongation of the axis, throwing all the growth into the hybernacula and incipient leaves, both of which become unnaturally incrassated, and form a monstrous imbricated bud round the larva while it undergoes the different changes of its youth. The small tubercles on the leaves of the *Glechòma* are caused by a species of these insects.

Haltiàca oleràcea.—The turnip-fly or beetle is a most injurious insect, as well in gardens as in fields. Every species and variety of the *Bràssica* family are preyed on by this fly, and in some seasons occasion great loss of time and labour to the farmer. They first appear in gardens, early in the spring, on radish, cabbage, cauliflower, &c, feeding chiefly on the semi-

nal leaves which, if they destroy, occasions the loss of the plant. They attack the turnip plant as soon as it appears above ground, and it is astonishing how soon a field of ten or twelve acres is eaten off. To this disappointment and loss the farmer must submit, and sometimes thrice in the same season, there being, as yet, no effectual preventive discovered to defend the crop. The most successful management for preserving a crop of field turnips is by sowing drills of the kind intended to stand, rather thinly, alternating with drills of another sort, sowed thickly; the latter will be preferred by the flies, and devoured while the first grow out of their way: the supernumerary drills, if any of the plants escape, are afterwards hoed up. We know very little of the economy of this insect; like other beetles it passes the three first stages of its existence in the ground, and comes forth sooner or later in the summer according to the heat thereof, or as the chrysalides are exposed on the surface by the plough; many farmers being of opinion that the aration necessary for the turnip plant, serves to awaken the sleeping insect.

We had been acquainted with this beetle and had suffered much from its ravages many years, without ever being able to witness its flight; but one day (20th July last) passing along the Fulham road, and opposite a piece of turnip saved for seed in the nursery of Messrs. Harrison and Bristow, we found several of the insects on our dress, and saw thousands sporting in the sunbeams over the crop. This circum-

stance shows the fallacy of those arguments in which it is stated, that sowing ten days after the turnip land is ploughed, or fallowing two years successively will destroy or banish the insect from the crop.

Cecidòmya tritìci.—We are indebted to Messrs. Gorrie* and Shirreff for almost all that is known of this silent working, and generally unnoticed enemy of the farmer. Entomologists had long ago enrolled this insect in their lists, but they were not aware of the destruction it causes to the wheat crop. This small fly generally makes its appearance along with wheat-ears, i. e. about the middle of June. "They seem at first to frequent the vegetable kingdom indiscriminately, but soon congregate in wheat fields, and remain during day on the lower parts of the plants. About sunset the fly becomes active and continues so till sunrise. Possessing a hair-like ovipositor of considerable length, the parts of which slide from each other like the tubes of a telescope, by which the eggs are deposited in clusters, visible to the naked eye on the inside of the chaff, commonly when the ear is escaping from the sheath. The maggots, when ushered into life, are very small, and perfectly translucid; they soon increase in size, and become yellow coloured. They seem to subsist in the first instance on the pollen, and latterly on the matter which would have formed the grain. They possess not the power of moving from one cup to another,

* Of Annat, Perthshire.

and finally leave their birth-place a few days before the plant reaches maturity, and reside in the earth during winter, a discovery which belongs to Mr. Gorrie."—*Mr. Shirreff in Q. J. Agri.*

The same enlightened agriculturist is of opinion that no effectual check can be given to the depredations of this insect, unless a variety of wheat be obtained whose chaff envelopes the cups so closely as to be impervious to the ovipositor of the insect. This insect is known to exist in all parts of Britain under the name of red-gum ; but its ravages have been particularly severe for several years past in East Lothian where Mr. Shirreff resides, and who calculates that the wheat crop has been damaged to the amount of 30 per cent.

Wire-worms.—The larva of the *elater castàneus* is a tough, yellow, smooth, grub, with a brown head, and about three quarters of an inch in length. They are found in all sorts of soil, particularly fresh loam, and in old leys newly broken up. The root of every plant in their way appears to be preyed on by them ; causing great loss to the florist by destroying his bulbs, as well as to the farmer's crops of oats and wheat. There are several other worm-like animals called by this name, one is the larva of a *Styphalìnus*, and the common one, so destructive to onions, is a minute species of *Scolopèndra*. Dressing the land occasionally with lime is the best defence against such enemies, as well as against all the species of *Mollùsca* so hurtful to all young vegetables.

Fingers and toes, or clubbing.—This is an attack of an insect called *Nedyus contractor.* They choose the under-ground stems of almost all the *Bràssica* family as a nidus for their young, inserting their eggs into the vascular pulp beneath the cuticle, where they are hatched, and pass the maggot stage of their life, during which they subsist on the interior, whilst the bark, as it may be called, is monstrously swelled over the inclosed worm. Their presence and havoc within, derange the organisation, diverting the current of sap so much as greatly to disfigure and injure, if not totally kill, the plant. Cabbage, turnip, broccoli, and many others of the tribe, are the usual prey of this tiny foe. Dry situations, or soils, seem to be more subject to the visits of the insect than others; but luckily it has been lately discovered, that any alkaline substance incorporated with the soil defends the plants growing on it from being chosen by the parent fly. Soap boilers' waste is particularly efficacious for this purpose; and no doubt all other substances, of similar quality, would be equally serviceable.

The Weevil, (*Curcùlio granàrius,*) is destructive to wheat stored in granaries. It is said that if an unwashed fleece of wool be laid near the corn-binn, the weevil will prefer this to the wheat. Other *Curcùlios,* in their perfect form, feed on the young shoots of apple trees; one of the most destructive in nurseries, is about two lines in length, lies hidden in the ground by day at the roots of trees, after sunset they crawl up the stems and eat out the buds,

especially of new budded or grafted plants, causing a serious loss to the nurseryman. Being a hardy insect, they cannot be assailed by any nauseous dilution or powder applied to the soil; but probably something of the kind thrown on the stems and heads by a syringe might protect the buds.

Red Acarus or Tick.—This is commonly called the red spider. They are a minute apterous insect, though a great plague to the forcing gardener. It infests the leaves of vines, peach-trees, and almost all other plants in the stove or hot-house; puncturing the cuticle of the leaves and young shoots to extract the sap, and causing its escape, so that the parts lose their vitality and die. This insect is called a spider, because it spins or ejects a web, not for the purpose of entangling flies like the true spiders (*Aranea*), but for forming a kind of defence against humidity which is most annoying to them. Indeed a moist atmosphere, and water frequently and forcibly applied, is a good remedy to banish and prevent their increase. But sometimes they become so numerous in collections of plants to which excessive watering would be prejudicial, that it is necessary to extirpate them by suffocation, which is done by the vapour of flour of brimstone smeared on the hot flues of the house, or from a chafing dish made for the purpose. It has also been found that copious moisture with a very high temperature will expel these insects. There are several other plant ticks, that are comparatively harmless. One sort lives on the leaves of grass, causing

those yellow spots on the sward often visible in autumn.

Thrips.—Are a very small apterous insect, about one third of a line in length, resembling an aphis; having two lateral appendages instead of wings. They gnaw the cuticle of the leaves, and extract the juices in the same way as the red acarus, with which they are often associated in hot houses. They are got rid of by the same means, though with more difficulty than the latter insect.

Formica.—Ants are sometimes useful, and occasionally hurtful to plants. Wherever the aphides are seated, there also are ants busy; they collect the honey-dew voided by the former, and if there be not a full supply of that substance they take the young insects themselves. In this they are serviceable to gardeners. But in early forced peach-houses, for want of other food, they betake themselves to the blossoms, and eat or gnaw off the filaments, to the manifest injury of the flowers, and consequently of the fruit.

Forficula.—Earwigs are well known to be injurious to both flowers and fruit. They, the ant, and the wood louse (*Oniscus*) are easily entrapped by placing hollow tubes, baited with sugared water, near their haunts.

Gooseberry and Currant Moths.—The caterpillars of these insects are particularly destructive to these small fruits. Lime water repeatedly applied, and the ground under the trees dug to bury the fallen cater-

pillars, is one method to destroy them. They may also be driven away by fumigations of sulphur, or other suffocating effluvia.

The foregoing, and many other insects, are found on cultivated plants, which are all more or less injurious. To be acquainted with their names, economy, and with the methods of killing or banishing them, is of material consequence; but as "prevention is better than cure," the whole attention of the cultivator should be directed to this point. It is often seen that plants, subjected to the attack of insects, or of a peculiar injury in one season, are particularly liable to be again affected in the next. It is expedient, therefore, that the application of remedies precede the attack; if peach and nectarine trees were periodically washed with a lixivium of soap in the course of the autumn, winter, and spring, it is not probable that mildew would appear on them in summer. And where the visit of the aphides may be expected on trees, the autumn is certainly the season when they would be most effectually repulsed. It is in this season that the eggs of insects are deposited on those plants or substances which yield convenient sustenance for their young. With this view the careful mothers seek the furrows of the bark, the indentations round the buds and branches, as safe depôts for their ova. But did they find these recesses already occupied by any quality offensive to them, they would be disgusted, and seek a place elsewhere. The aphides are viviparous in warm weather, and oviparous when

it is under 50° of Fahrenheit. The first broods in the spring issue from eggs deposited on their favourite trees in the previous autumn; and from these all the sequential broods of summer proceed. Rose trees require to be particularly well guarded against these autumnal depositions. Other insects besides the aphides choose this plant for their young, the larva of which roll themselves in the leaves, or eat a way into the flower, but which they devour before it is expanded; in like manner many other fruit and flowering trees are damaged. If then any easily distributable matter, either dry to be applied with a puff, or a liquid discharged by a syringe, were given from time to time in the autumn, there is no doubt of its operation as a defence. In fact it is only making the plants disagreeable and uninviting to the parent insect, that will save it from the ravages of the offspring.

Salts, particularly alkaline salts, lime, sulphur, or other mineral substances, and all pungent decoctions, are to some one insect or other either offensive or fatal: and many vegetable qualities doubtless there are, which, however innocuous and even nutritious to the human frame, may be highly disgusting to many insects which annoy us. Such are desiderata yet to be discovered by attention and experience; and, in the search, it should be remembered, that the human palate and that of insects are dissimilar; the aphides riot on the hop, the elder, and other bitter plants, but which, perhaps, would quickly perish on

some of what we consider vegetable sweets. It has been affirmed that potato water showered on gooseberry and other fruit trees preserves them from caterpillars.

Connected with this subject may be mentioned the protection of old ornamental trees, which suffer, or are supposed to suffer, from certain insects which breed in timber. Many stately trees in the gardens of colleges, palaces, and in public malls in cities, have been prematurely killed, it is said, by the larva of the *Scolytus destructor*. Whether they cause the injury in the first place, or are only attracted by the already decaying members of the tree, is variously understood, but the latter circumstance is the most probable*. Trees in public places are liable to many accidents which such as stand in the forest escape. The former are exposed to injuries from the knives of silly people, bruises from the roller, spade, or sithe; these induce decay; this invites the insects; their depredations increase the wounds and prevent recovery. That such accidental bruises may not increase to endanger the life of the tree, the best thing to be done is scooping out all the decayed parts both of bark and wood, and covering the wound with a good coat of tar, in which a little tallow and saltpetre is added, to be renewed, from time to time, if

* This has been satisfactorily proved in an excellent paper, by the ingenious Mr. Denson, senior, of Water Beach, near Cambridge, author of the "Peasant's Voice."

exhaled away. This application will prevent rapid decay, offend the insects, and assist the creation of a new bark over the scar.

Besides the insects already described as living on the exterior of trees, there are several which are bred in the interior and feed on its living members. The *Cerambix gigas* inserts her egg in the pith of apple trees, willows, ash, Scotch pine, and even the oak. The maggot eats its way upwards, excavating and subsisting on the material of the pith and wood, leaving behind a hollow passage of not less than one-fourth of an inch in diameter. Before its last transformation it eats a way out of the wood, and reposes in the bark in the pupa state, whence it comes forth a large winged insect. Among sawyers they are called *Wurnalls;* and from the size of the trees in which they have been found, and the length of the passage made by them, they must have existed as grubs for several years. How or when the egg is placed in the pith is not known. The damage done to timber after being converted to domestic uses, by boring insects, is too well known to require comment.

FELLING TIMBER.

THIS business of the woodman is usually performed in the winter, on all kinds of trees except oak, and some other kinds, which are not felled till the bark "will run," that is, soon after the bursting of the buds, when the sap is most fluid and in motion. Trees having a resinous sap may be felled at any time, because it being less fugitive the timber is less liable to rend in seasoning.

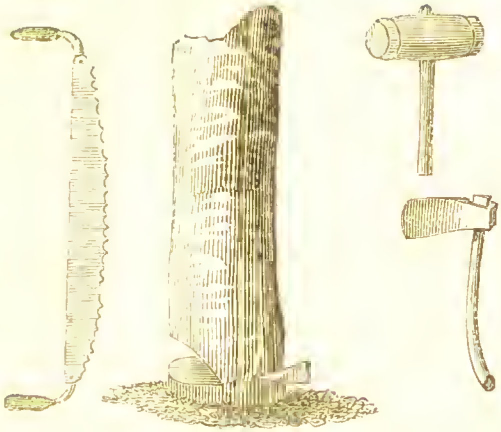
Trees are either felled by grubbing or cut over by the saw. The former method may be done in the case of single trees, but in thick standing woods, cutting down with the felling saw is not only the most expeditious, but, as the tree may be thrown in any direction, it is the most elegible, no damage being done to the surrounding trees.

Grubbing, that is, first baring and cutting all the roots, is sometimes preferred, because it is thought that a little more timber is obtained thereby, and also that the roots, being at onee got up, are easier cut from the butt and got rid of, than grubbing them after the tree has fallen. But this is denied by the best woodmen, who assert that a root, while fast in

the ground after the bole is cut off, yields to the action of the beetle and wedges, pickaxe, and dog-iron, much more readily than if lying loose on the surface. Besides, in the attempt to fell a large tree in this way, much time is lost in endeavouring to reach the "tap roots," while the tree is expected every instant to fall.

Felling with the saw is therefore the preferable mode, and the manner of doing it is as follows: The workmen first fix where the tree can be most conveniently thrown; this is determined by there being a proper opening to receive the head, and without fear of damaging other trees in its fall, and also that the branches of the tree to be felled are so balanced as to number and weight, as not to swing the tree aside while falling to the ground. These circumstances considered, a deep triangular notch is cut at the bottom of the bole, on the side next to and at right angles to the line along which the tree is intended to be laid. This notch is called "the fall," and requires some judgment in forming, because its inclination entirely regulates the fall of the tree. The base of the butt is then hewn down perpendicularly all round, the projections of the spurs cut away as low as the horizontal face of the fall, so that a plane is formed on which the saw traverses flatly in its progress through the stem. (Fig. 60.)

Fig. 60.



Manner of felling timber trees, with the necessary tools.

This plane is always formed as close to the ground as possible. The saw is then entered on the side of the tree opposite to the fall; and as soon as it has passed far enough within the stem, so as to admit a thin wedge, one or two are entered behind the saw, in order that it be not pinched in its play. As the saw proceeds, the wedge or wedges behind receive every now and then a blow of the beetle, in order to keep the tree steady in its place. The saw is worked parallel to the cross cut of the fall; and is continued towards it, till about an inch only of sound wood remains. The wedges are then beetled till the tree falls; and this, if the inclination of the fall and the action of the saw have been made to correspond, takes place with admirable exactness. It sometimes happens that, from the unequal distribution or unequal

length of the branches, the tree threatens to fall out of its course; this is discovered by one of the wedges going easier than the other, or the saw pinching on one side and not on the other; in this case the saw must be worked more on the side to which the tree threatens to swing, and thereby giving way first at the final driving of the wedges, allows the tree to fall in the intended place.

It also happens sometimes, from unskilful management, high wind, or unfavourable leaning of the tree, that when the saw is nearly home, and the wedges have not a sufficient bearing, that the tree will suddenly fall over them; this is an accident often attended with danger to the workmen, and should be carefully guarded against.

When the tree is fallen, all the branches and head are cut off, leaving the measurable timber. The branches, if too small to be measured as timber, are cut into lengths of six or eight feet for billet wood; the smaller are chopped into three or four feet length for stack wood, and the brush is tied up in fagots about fourteen inches diameter, for the purpose of heating ovens, or burning bricks. These fagots and stackwood, being about the same length, are usually disposed of together; two pieces of the latter being counted as one fagot.

In felling oak, the same steps are taken as above, but with the addition of stripping off the bark from the butt and branches before fagoting, as far up as they are of any size. The bark is first cut through

across, in lengths of three feet, with the hand-bill, and with its point ripped longitudinally into slips, from six to twelve inches wide. A barking-tool, somewhat like a crutch hand dibber, shod with iron, flattened at the point in the shape of a crescent, the stalk a little bent to follow the rotundity of the tree, is then inserted and pushed under the slips of bark, which fly off with the greatest ease. The bark being thus peeled off, it is afterwards set up to dry. This is done by driving a rank of stakes, (cut from the spray) into the ground about two feet high, having a forked top to receive poles reaching from one to the other. Against this temporary rail, the slips of bark are set up along both sides, pretty closely together, the rough side outwards; and along the top some of the widest slips are laid to form a coping. When bark is thus set up, it is sold at so much per yard run.

In some places the custom is to disbark the trunks in the spring, and fell the trees in the following winter; and this with the view of having superior, because winter-felled, timber. That timber felled in winter is less liable to rend in seasoning is well known, and this in consequence of the juices being then coagulated, and almost stagnant; in which state it is preserved in the timber, and not suddenly exhaled away, as would be the case in summer, when the sap is thin and fugitive. The woodman and carpenter incessantly repeat the traditional maxim of their forefathers, that winter-felled timber is more ponderous

and durable, because in that season "the sap is down." We have already adverted to, and commented on, the accuracy of this old notion, and have shown, that, however right the practice of felling timber in winter, the woodman's reason for doing so is not strictly philosophical. But this is of little consequence, so as the practical old custom is right.

Of the oak we may observe, that disbarking and killing the tree before it is felled, cannot answer any material good. The stem will continue to imbibe water as long as it stands, though deprived of bark; and as all aqueous sap must be exhaled away before the timber can be used with propriety, little time is gained by this scheme, and no great superiority of quality. It is only the sap wood, or recent layers of alburnum, that suffer by being too quickly seasoned, and this is never, or should never be, used in machinery, ships, or other structure where heart-wood is particularly necessary.

With respect to the propriety of disbarking timber in general, we know that in some instances it is right, in others wrong. The peculiar qualities of the tree are often found concentrated in the bark. If these qualities be conservative, persisting, and moreover repulsive to insects, it is wrong to deprive such trees of the bark, when the whole, or parts of the stem or branches are used for any purpose of buildings or fencing: of this description is the larch. On the other hand, if the bark contains no conservative principle, and be attractive and retentive of moisture

so as to induce early decay, the sooner it is hewn off the better. While the bark on any fallen tree remains sound, it defends the wood from being cracked by the sun and air ; but it should not remain after it is rotten, because it forms a harbour for many insects which prey on the wood.

Fir and pine timber may be, as before observed, felled at any season ; because the sap being gross and resinous, is less fugitive than that of deciduous trees. It is also to be remarked of pine-trees, that whereas deciduous kinds become decomposed first at the pith, pines are first decayed on the exterior, owing, no doubt, to the internal store of preservative juice.

The quality of timber of every kind of tree is always found to be in the greatest perfection when grown on land which is naturally most suitable to them. The most valuable properties of timber are solidity, ponderosity, toughness, and durability. Rapidity of growth gives a coarser grain, and also greater strength of fibre. An oak raised on a sandy or moor-earthy soil, yields timber of a milder texture or grain, than that from off loamy clay ; but it is also less tough, and probably less durable. The durability of oak depends on the strength of the fibrous structure forming the vascular parts of the wood. The fir shows that its cellular members, namely, the exterior side of each year's growth, resist decomposition for a longer period than the intermediate portions of the wood. We have only to look down on an old deal floor to be convinced of this fact, and to an old oak

gate-post, much grated and worn by wheels, to be satisfied of the other.

Felling Underwood.—Underwood is felled periodically at intervals of five, ten, or more years, according to the superior growth of the stuff, or the purpose for which it is wanted. In value it varies from 5*l.* to 15*l.* per acre, according to the size or age of the fall. A thriving underwood of mixed, useful, kinds, may be felled every seventh year, and yield a variety of produce, as hop and hurdle poles; mop, rake, and broom handles; long rods for crate and basket making; hoops and headers for fencing; five feet and four feet stakes for ditto; withes, pea-sticks, and fagots.

The woodman begins by cutting down hand smooth, every shoot, as low and as smoothly off the stubs as possible; laying the stuff indiscriminately, in large heaps, behind him. This he performs with a stout bill-hook, and a light narrow axe. When he has cleared a sufficient space—so that carrying the stuff to the heaps is no longer convenient—he next proceeds to trimming. With a light, keen, trimming bill, he takes the first pole, rod, or stake that comes to hand, and having trimmed and cut it to the greatest, or desired length, throws it to the place intended for all of the same description. Thus he proceeds till he has trimmed all that is down; occasionally fagoting up the brush as it accumulates in his way. The next step is tying up the stuff; poles are taled and sold by the hundred, but not tied

up; rods, hoops, pea-sticks, and four-feet stakes, are bundled in fifties; withes in hundreds; mop or broom stakes in sixties; five feet stakes, &c., in quarter hundreds;—all which bundles are commonly sold at the same price, varying from eight pence to one shilling each. The woodman is paid three half-pence the bundle of common stuff; and two shillings the hundred of poles; and one shilling and two pence for fagots.

Well planted, and judiciously-managed underwood, is a profitable disposition of land unfit for other purposes; and as it yields, or may yield, an annual income, is always an object of interest with the general planter.

Grubbing.—Taking up the roots of felled trees is one of the tacts of rural economy. Rude and homely as the task appears, it requires no small degree of mechanical power, and judgment in the execution. A good grubber is a person of some eminence in rural society: many spending their whole lives in such labour without acquiring a competent knowledge of the business. An old expert grubber with comparative ease to himself will earn his three shillings a-day; while the athletic, young, but inexperienced hand, will be sadly distressed in earning half the money!

A spade, mattock, pickaxe, beetle, dog-iron, a strong lever and rope, and a set of twelve iron wedges weighing from one to five pound each, with a large wooden one, are the grubber's tools. He first

clears away the earth from off the root to the distance of five or six feet from the centre of the stump: cutting through the diverging spurs close to the outside of the opening. This done, he next considers where he had best insert his wedges; and here, if he has not an intimate knowledge of the physical structure of the whole root, he will certainly waste much of his time and strength in vain. He should be aware, that to the original axis of the seedling tree, all the exterior accretion has been in the course of time imposed; and that the sides of the stump can only be split off in the same order and direction in which they were laid on. His best plan is to endeavour to split the crown into segments, and then reduce each of these segments by taking off slivers from the outside. But in forming these segments, much judgment is necessary. Every species of timber has a natural cleavage; and this it is that directs the position of the wedges. Right lines, from the pith of the stem to the centre of each spur or large root, are the proper places for insertion of the wedges. Spurs cannot easily be separated from each other, after they are united in the collet; because the grain lies horizontally from one to the other below. If the division into segments (which is usually done seriatim) be accomplished, the rest of the labour is easy; as these are reduced by pieces consecutively detached from the outside.

Pieces of large size, when split away from the crown, are often held by tap, or downright roots

belonging to them. In these cases, the dog-iron and lever are applied to wrench them off. The dog is a strong hook having a straight shank ten or twelve inches long, with an eye in which a stout ring traverses. The lever passes through the ring, and when raised upright—its lower end abutting on the base of the root, and the dog fixed above—it is pulled down by the rope attached to its upper end. The dog and lever save much labour in doubling wedges and beetling; and with the assistance of the large wooden wedge, which drops down in the cleft while the lever is worked, greatly facilitates the division of the root.

The further duty of the grubber is to level the ground and stack the roots. This last is placing them on a level surface in stacks closely piled together three feet in width and height, and as long as there are roots to fill up. Every four feet in length is accounted a stack; and by the number of which the grubber is paid according to the value. The wages being always somewhat less than what the roots will sell for, viz. from four to six shillings per stack.

Grubbers prefer taking up roots in the second or third year after the tree is felled; because the fibres are then all dead and have lost hold of the soil, and then also the root is not so much decayed as to refuse the action of the wedges. A doated, or rotten root, is much more difficult to be split in pieces than one that is sound.

Longevity of Trees.—It has already been men-

tioned, that all vegetable matter is, during growth and for some time after it is perfected, preserved from decay by the life; and after this has entirely left, it endures for an uncertain period before its final decomposition by the vicissitudes of weather. The natural death and destruction of a tree happens in consequence of the wood, in the greater number of kinds, becoming rotten at the core, which defect continues to increase outwards till the whole axis is perished; of course the tree is then shattered to pieces by the wind.

The age of trees, when no record of their planting has been kept, cannot be ascertained until they are felled; at which time the concentric layers composing the axis may be seen and numbered; the amount from the pith to the circumference being equal to the age of the tree, or, in the pine tribe, the number of knots from the base to the apex of the tree. This cannot be done accurately unless the whole butt be sound; because if the tree has stood beyond a certain time, a portion of the centre will be rotten, and then the age can only be guessed at. Nor, even if the age were ascertained, would it be a criterion for judging of the age of other trees of similar magnitude, unless the soil and situation in which they grow be exactly alike.

We have histories of remarkably large trees growing in different parts of the world; as some of the *Bombàceæ* in Africa, the figs of India, the chestnuts of Sicily, the cypresses of Mexico, the pines of Cali-

fornia, the elms and limes of France and Germany, and the oaks of England. The circumferential measurement of many of these stupendous plants is immense; but the greater number are hollow, except perhaps the pines and others having a resinous sap. Many trees of large size which appear sound, are, perhaps, only hollow tubes. The knowledge how long a tree remains sound is yet to be acquired by future generations, as it is but lately that attention has been called to the subject.

The general opinion respecting the age of trees seems to be, that when known great age and bulk are united, it is ascribed to the suitableness of the soil and situation. It has been proved, that the best oak timber is produced on loamy clays; and when a tree is suffered to remain for many years on such a favourable spot, its bulk will be in proportion to its age. But whether, after all, internal decay be retarded by the favouring situation, we have yet to learn. A period of three centuries is traditionally given as the age of the oak, viz. the first increasing — the second stationary — and the last falling to decay: but this is but conjecture; though it may be safely affirmed, that oak of a century old, having both bulk and quality, is the best for every purpose to which it is convertible. The largest trees in England are such as have been planted or chanced to stand in church-yards, or near baronial halls; and which have been spared from age to age as objects of ornament or landmarks, or memorials of eminent

persons, or remarkable events. But these are of no value as timber; nor ought the growing, or even the possession of very large trees to be an object of ambition with the mere profitable planter.

The strength and durability of oak is said to be always in proportion to the quickness of its growth. But in the case of Scotch, and, perhaps, other pines, the reverse is the consequence.

CONCLUSION.

In the foregoing pages, it has been endeavoured to present a plain and concise view of the various structure, functions, and properties of plants. The most ostensible and strongly marked characteristics have only been regarded, because these are what are chiefly required to be known in the business of the cultivator. The writer is well aware, that, by close study and the assistance of a powerful microscope, more correct descriptions and precise representations of the elementary matter, motions of the fluids, and connection of the organisation might be given; and, moreover, if chemical knowledge were employed in the study of vegetable physiology, many discoveries might be made, which would illustrate the causes of the change of colour, manner of accretion, and some of the diseases to which plants, or parts of plants, are

subject. But this prosecution of the science must remain for the research of others. Such desiderata will always be an inducement to those engaged in the study or cultivation of plants, to advance physiological knowledge, and complete the imperfect sketch herein-before given.

By attending to the appearances of plants in every stage of their growth, and marking the changes which take place as they pass from one state to another, thereby tracing effects to their causes, is the only way of gaining a complete knowledge of the phenomena of vegetation; and, when thus attained, every manipulation to which plants have been, or may be subjected, will be readily and unerringly applied.

The principal features of the book will be found to be descriptions of the organs of plants—the proper distinctions of stems and roots, which have not been before defined with sufficient accuracy—the constitutional structure and development of bulbs and tubers—the progressive growth of new wood and bark, and other processes of vegetation, as exemplified in trees and shrubs.

A few practical essays are added on the principal operations of the gardener, woodman, and husbandman, showing the application of physiological knowledge, and serving as proofs of various assertions made in some of the foregoing sections.

In arriving at the various conclusions stated in the foregoing pages, besides our own practical tests of many previously published opinions, we have to

acknowledge the great assistance we have derived from the elaborate drawings and descriptions of the stems of dicotyledonous plants, by M. Mirbel; to those in Dr. A. T. Thomson's Botanical Lectures; and particularly to the elegant delineations of W. W. Capper, Esq., of Bath, in his lately published descriptions of the Anatomy of the Vine, as corroborative of many of our previously formed notions on the subject.

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THE END.

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